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THE AMERICAN
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VOL. 105 MARCH, 1933 No. 3

EDITORIAL

TECHNOCRACY AND THE DRUG STORE

THE up-to-date drug store has, in some respects, turned technical. It is run mechanically. Engineering systems, supersalesmanship, efficiency methods, have been established. Charts govern sales, volume, turnover, expenditures, profits. The apothecary shop, the corner drug store of other days, seems to have gone "technocratic," if you know what that words means.

It all belongs to the age in which we live. Art, science, literature, sports, are governed by an engineer. Even life itself is molded according to a chart.

This trend has likewise encompassed the art of healing. The old-time family doctor has gone, and in his place has come the specialist. It is quite true that in medicine and surgery miracles are performed every day; the hands of disease and death are stayed, and the span of life prolonged. But the patient has become a "case." He is not a human being. He is diagnosed in a laboratory and run through a machine according to a schedule. The patient is cured, but the sympathy, the spirit of the healing art, the old-time humanities, are lost in the whirl of the revolving wheels.

This is a day of frenzied merchandising. It has been tritely said that—"the druggist is a merchant whether he sells ipecac or lip stick." The drug store has become a merchandising mart. The sweetest music to the ear of the druggist is the ringing of the cash register. He must strive for more business, more sales, more volume, more profits.

The druggist's shelves are filled with ten thousand or more items. These are placed there in part to fill the demands of his patrons, and also partly of his own volition. Through the long drug store day there is a continuous pell-mell, rush and push, wrapping up wares,

taking in money, ringing up the cash register, giving change, and reaching for the next customer.

Sales days, bargain days, sales weeks and drives follow each other in quick succession. High power salesmen fill the shelves with schemes, deals and bargains. The drug journal pages are crowded with bewildering suggestions as to window displays, store displays, counter displays—schemes to make more sales and increase business.

We live in a machine age. We are told that humanity is becoming engulfed in the machine of its own creation. At times the art of pharmacy seems to have become enmeshed in the woof and warp of the fabric it has woven around itself.

One cannot attempt to read, much less digest, the pages of our journals filled with long dissertations on pharmacy, pharmacology, pharmacognosy, biology, bacteriology, radiology, immunology, discussions of energies, and a host of other things named and unnamed. The brain of the pharmacist becomes twisted when he attempts to keep pace, even in a small measure, with the progress of modern pharmacy and science.

Walking up and down in front of his counters, the druggist sees a confusing array—a few drugs; thousands of things other than drugs, bearing tickets and legends of cut prices; goods sold at cost, and below cost; "loss leaders." Up and down the street and across the way are cut rate shops, beauty shops, pine board stores—all striving to direct patrons to their shops.

But the picture is not all dark. There are rifts in the clouds. The art of medicine is moving onward with sure rapidity. Pharmaceutical education, association, work, legislation—all are moving forward. Every twelve months sees the pharmacist in an advanced standing.

Where can the poor druggist fly to escape this turmoil? The technocrat would tell him that he needs an engineer, an efficiency, resource, or production technician—a technocratic economist, whatever that may mean. Just what the druggist could do with this sort of technician is still a problem.

However, there are certain things a druggist can do, and still carry on his business at the same old stand. He can become his own engineer; he can survey his own business; chart his own store. He can clean up his own yard.

The technocrat in his survey excludes prices, profits and private gain, and builds upon a foundation of tangible performances, and

tangible benefits to the community. Under technocracy, for the purpose of study, we shall exclude for the time the spirit of gain, which rules our lives, and substitute for it a spirit of service. In our minds, for an hour at least, we can assume the role of a princely benefactor.

What can be done to give to the community, and the throngs that enter our store, better service?

What can be done to supply our patrons with better goods—eliminate all shams, deceits and trickery?

Every label is to tell the truth. The patron will know what he is receiving; its nature, purpose and use. He will be guided by his selection. He may not always receive what he asks for, but so far as possible he will receive the thing which will give the best results.

Patrons will be warned against fraud, deception, and misleading statements which may have been promulgated in respect to the article in question.

Every prescription or mixture will be compounded with the highest grade of material, and put together in strict accordance with the rules of the art of the apothecary.

Trust, honor, integrity and faithfulness will govern every transaction.

The pharmacist is to assume the role of health advisor to the community in which he lives. He will support every civic movement which may involve the health and well-being of the inhabitants.

The pharmacist is to enter the home of his patrons, friends and neighbors and, with diplomacy, become the home health advisor. He will survey the home, and recommend, persuade, exhort in all matters pertaining to the health and well-being of the inmates.

From the technocratic viewpoint the pharmacist becomes a health engineer. Food, clothing, light, heat, ventilation; the control of contagion, the prevention of disease; anything and everything pertaining to the health of those committed to his care, belong to his realm.

In making a technocratic survey, the druggist will not overlook his own store. He will, perhaps, rearrange, revamp, recreate the structure. He will make it a pharmacy. Its appearance, its arrangement, its atmosphere, will be that of a place where health and well-being are dispensed. All activities of the place will be subordinated to pharmacy. The technocratic drug store or pharmacy will be a place to which its patrons may resort to obtain things which will help to restore their health when sick; things to prevent them from becoming

ill; things to keep them in health; things that will "render them fit to live most and serve best."

A technocratic view of the drug store involves a survey of life itself. There is required an unemotional, sane, intelligent attitude—as Salesby said, "that fine temper, half philosophic, half religious, half intellectual, half emotional, half rational acceptance, half faith." The problem must be approached with an open-mindedness and breadth of view. One must look beyond the walls of his own store, see new relationships, feel new meanings and find new values—a newer view of life itself. One must assume an unselfish attitude. "The permanent satisfactions in modern society come from unselfish service to the world."

The mind of the druggist, while making a technocratic survey, will swing back to the cash register and the balance sheet. He asks: "If the spirit of service, and not the spirit of gain, is to rule my store and my life, who will pay the bill? Who will satisfy the wholesaler, the landlord; meet the clerks' salaries, care for the mounting expenditures, and provide for my family?"

This is a very human point of view. It is, nevertheless, tinged with selfishness. It is inspired by a lack of faith, courage and confidence in the goodness of the world. The "lean, starved apothecary" was of Shakespeare's time, not ours. "Service to the community" is not listed as among the "causes of failures among drug stores."

Some one has compiled a list of over three thousand drug stores which are classed as "prescription stores" or "ethical pharmacies." Incidentally, these stores are recorded as A-1 on the credit lists. Some of them have prospered through several generations.

Slowly, but persistently, the trend is toward "ethical" pharmacy. Pharmaceutical education is moving in this direction. Graduates in pharmacy are pre-eminently fitted for service.

If we look about we will find that there are professions in which service, rather than gain, rules the lives of the followers. Examples of these are teachers, ministers, and our allied calling—physicians. Here monetary gain is subordinated. Lives are given over to the service of humanity. They do not starve. They pass on, carrying honors gained in their service to their fellowmen.

The world has changed, and is still changing. It may be that our dream of technocratic pharmacy and a technocratic drug store will, in part, at least, come true.

FRED. B. KILMER.

ORIGINAL ARTICLES

ADVANCES IN PHARMACY THROUGH SCIENTIFIC RESEARCH [1]

By George Denton Beal [2]

Foreword

I FIND it difficult to express in fitting terms my appreciation of and my gratitude for the honor that you have bestowed upon me this afternoon. From boyhood I have had great admiration for the Philadelphia College of Pharmacy and for the distinguished gentlemen who have composed the faculty and alumni groups. While I did not exactly learn my alphabet from Remington's "Practice of Pharmacy," I pored over its pages with fascination, held almost spellbound by the wonders of theoretical and operative pharmacy. When I became old enough to pack a percolator I was thrilled by the fact that I too was able to prepare a galenical of genuine medicinal value.

I later learned to use and to appreciate the wealth of information contained in the United States Dispensatory, and to respect the college for the striking part it has played in the preparation and promulgation of our magnificent United States Pharmacopœia. My work has at times taken me far away from pharmacy, but the lessons I learned from its books have been the greatest factor in bringing me what modest success I have obtained. I am glad that I have had an opportunity to do a little in keeping scientific pharmacy in its present place, and I thank you most sincerely for making me a member of your family. I promise you that I will, to the best of my ability, try to be a worthy member of your group.

Introduction

The purpose of this occasion is to commemorate the founding of an institution of professional training that, since its beginning, has stood for progress in the science and art of pharmacy. All American pharmacists, and their chemical and medical relatives, honor it for its

[1] Founder's Day Address, Philadelphia College of Pharmacy and Science, February 23, 1933.

[2] Assistant Director, Mellon Institute of Industrial Research, Pittsburgh, Pa.

scientific achievements, not only in contributing to the healing of the sick but also in the development of the pharmaceutical and many of the chemical manufacturing processes of today. Chemistry, physics and biology have developed experimentally through the art of the apothecary, and the chemical and pharmaceutical manufacturers operating today owe much to those men who studied and standardized the methods of pharmacy.

A second purpose is to do honor to one who has spent a half century in active work on behalf of the Philadelphia College of Pharmacy, laboring in his chosen field of chemistry. I am sure that my fellow chemists throughout the world will join with me in extending felicitations to Professor Moerk, and in hoping that we will find the next fifty years of chemistry as fascinating as the last five decades have been for him.

One wonders what these coming years will bring forth, whether they can possibly equal in importance of discovery the fifty just past. But doubtless this same question was asked at the beginning of that period, just as it is asked every year. This last period has produced all of that part of theoretical chemistry that we call physical chemistry, and the main portions of biochemistry and the science of nutrition. But the preceding period gave us organic chemistry and the fathers of analytical chemistry. The *Zeitschrift für physikalische Chemie* appeared first in 1887, and the initial volume contained the article by Arrhenius in which he propounded the electrolytic dissociation theory, upon which we base our modern concepts of analytical and physical chemistry. In the previous period, however, Mendelejeff described the periodic arrangement of the elements and Cannizzaro developed the application of Avogadro's hypothesis, thereby bringing law and order into chemistry. X-ray analysis today is exposing the hidden structures of animate and inanimate things, but the previous period gave us the spectroscope, which is revealing the constitutional mysteries of this and other worlds. If the public receives more benefit today from scientific discoveries, it is probably not so much because of the merits of the discoveries as their cumulative effects.

The practical applications of scientific principles evolved by seekers after new knowledge usually follow rapidly upon the investigations themselves. Man has seldom needed to wait long after the development of scientific facts in order to receive their benefit through the hands of technology in the form of increased degrees of well-being

and comfort. But today many allege that the products of technology are not an unmixed blessing, that the feast has become a surfeit, and that recovery can only take place after scientific treatment. Grave proposals are made for scientific holidays, for moratiums in research, for the replacement of financial credits with thermodynamic credits, and a host of other polypharmacal prescriptions are written to cure the ills of the body politic. As your guest I do not propose to trouble you with a new appraisal of what is wrong with the world today, nor to offer you another sovereign panacea for its ailments. I would like, rather, to try to show you in what way the methods of research are making contributions towards the progress of the world, and that the results of research, honestly administered, have brought to mankind his opportunity for a gracious living.

There is often a tendency to esteem the accomplishments of research only as they apply in the domains of one's special interest, and to look askance at what may be done in other fields. This viewpoint is sometimes found among students of the physical sciences, but they then make common cause against students of the human sciences. Such an exaggerated, and frequently bigoted, attitude is most unfortunate, because it is an indication of an unbalanced interest. If these persons demand respect for their accomplishments, they owe the same sort of respect to the abilities and accomplishments of others, regardless of the scope of their fields. Furthermore, there are few students who can work in an absolutely independent fashion. Each is indebted to those who have gone before him in establishing the broad aspects of the subject, and who by their work in even distantly related fields have made possible some of the methods of study now used. The general progress in science and art has been such that the knowledge of what has already been done in one's own and other fields directs and colors the path of his work and his conclusions.

The Methods of Research

Research in its truest and highest sense may be looked upon as the systematic quest for knowledge in any field of human endeavor. It is not, of course, the mere accumulation of a mass of data. It involves not merely the collection, but also the correlation and interpretation of the data in a logical fashion. Furthermore, the data to be of value must be accurate, that is, within the limitations imposed by physical laws, biological processes, or the deficiencies of the human

mind and hand in recording past events. Research to the uninitiated, has a mystic significance, implying something beyond the range of their every-day habits of thinking. A homely illustration will serve to show that this is not the case. A mere listing of drug store fires in Pennsylvania during 1932 could be only a portion of the groundwork of research. Such a list is of little human value, except to establish historical records. The tabulation may be made more interesting and valuable if the immediate cause of each fire is attached. A third step may be to determine from these listings the number of fires produced under each similar set of conditions; whether there are any seasonal variations in frequency; if the fires were alike in the inflammable material responsible; whether any single form of container for the offending substance was used, and whether the container promoted or prevented combustion; what outside influences such as light, temperature or shock played a part; and whether any particular standard of quality or purity, or juxtaposition to other materials, had a contributory effect. The study now, instead of being merely a chronology, will become a first-class investigation on the prevention of drug store fires, of value alike to architects, owners, tenants and underwriters.

The real value of such a study is reached only when it is shown that, by application of the knowledge gained, drug store fires are actually reduced in number or prevented entirely. This means either that deliberate attempts must be made to fire stores in which the supposedly correct practices are being followed, or that each condition established be tested on a small scale and the findings translated into good store practice. Such tests will demonstrate that what has been determined is not the result of chance, but something that can be depended upon time after time.

Control Is the Basis of Dependable Experimentation

Research is furthermore the means of ascertaining the results of agencies working under controlled conditions. The larger the number of conditions to be controlled, the more elaborate becomes the investigation. Control in a field of research consists of establishing the limits of variables in terms of some standard unit. When we establish a selling price for a farm product we do so in terms of an arbitrary monetary standard in the form of a value assigned to a certain rather rare commodity, the metal gold, selected in part because of its comparative rarity, partly because of certain physical properties it pos-

sesses, such as density, resistance to corrosion and malleability, and partly because in a period of even greater rarity and because of its decorative properties it acquired traditional values. We could monetize platinum, or tantalum, by virtue of certain desirable physical properties they possess, but because of the weight of tradition they would be resisted as expressions of monetary units. Tradition is the tallest obstacle to be surmounted in the progress of research.

Gold is a monetary unit, but only because it in turn is referred to a more basic unit, that of weight. Taking all of the units that enter into the establishment of standards for the measurement of the limits of variation, in practically every instance the final standard adopted is some physical unit based upon a natural condition of matter. Assume that we take the criterion of a nutritional agent to be the growth curve of a white rat. The units involved are length, weight and time. Of these, length is based directly upon some constant of the earth, or light; weight upon the gravitational pull of a standard limited in terms related to length; and time is determined likewise by indirect reference to the unit of length and checked by astronomical means. The primary units are therefore beyond human control, the latter only governing the accuracy with which those comparison pieces that we call standards can be calibrated.

Having established fundamental units in terms of natural phenomena, and compared our primary standards therewith to the best of our ability, the next problem is to prepare secondary standards that are directly comparable with the types of experimental phenomena that we wish to measure. Such standards may be like the growth-curves previously referred to, or some other condition fixed upon as a mean by reason of many measurements in terms of the primary standards, as the saponification number of a fat, the optical rotation of a sugar, or the alkaloidal content of a drug. But all of these so-called standards are merely expressions of functions in terms of an earth system of units.

It may be said that the real criterion, not only of scientific, but of all scientifically conducted, research is control. The behavior of an animal towards a new drug is checked against the known normal behavior of that animal, the combining weight of a new metal against the established atomic weight of oxygen, and a proposed economic law against the practical working of the same conditions in the history of the world. One of the greatest faults to be found with many who

propose systems of political, economic or moral reform, or who react against any proposal for reform, is that they will not agree to the performance of a controlled experiment. They are so certain of their ground, or possibly so arrogant in their reasoning processes, that they can admit of no possibility of fault in their plans or their reasoning, and therefore insist that we shall proceed along the lines of their program, or we shall not proceed at all. Such is the stuff of which filibusters are made. No sincere thinker, be he scientist, humanist or politician, objects to the control of his experiment, nor is too vigorously insistent that the old way, though of a thousand years' standing, is the best.

Somewhere in every investigation there must be brought into play whatever sort of quantitative sense the student possesses in order to evaluate data, whether obtained through search of the literature or as a result of the student's observations. George McPhail Smith, my one-time chief, always told our advanced students, when reviewing qualitative analysis, that an outline for the qualitative detection of the elements, in order to be authoritative, should be capable, with little refinement, of yielding quantitative data. This is a very fair statement to make. If a separation of elementary groups is not complete, those portions remaining in solution will inevitably contaminate the next group precipitate and quite possibly interfere with an identifying reaction. This attention to quantitative detail marks the serious investigator in any field, as it constitutes part of the control of the experiment. The economist must treat the subject of prices in statistical fashion, the engineer must balance his stresses, and even the student of literature must be aware of the geographic, political, and economic conditions that regulated the lives of the subjects of his study.

The observation of these experiences of investigators in other fields has strengthened my belief in the value of analytical chemistry as part of the fundamental equipment of pharmacists and chemists, regardless of the scope of their practice. There is no other branch of chemistry that can so successfully drive home the necessity for precision of operation, or the quantitative character of chemical laws. It is a mistaken notion on the part of many that any person is capable of making a chemical analysis. Any person of steady hand who will follow directions religiously may become a valued assistant in a routine control laboratory, and any research chemist may acquire enough of skill in the art to make analytical chemistry a valued tool in the lab-

oratory. There is still a third type of person to be mentioned, that person who has "quantitative sense" or "feeling." Such a person can convert a mere suggestion into a quantitative outline, can systematize laboratory procedures, and prove both an inspiration and a curb to the worker in synthetic fields. The functions of analytical chemistry are therefore not those of the analyst himself but its effects upon the habits of thought of those who have studied it understandingly. Just as an analytical procedure is divided into a series of classical steps, so does the solution of a research problem divide itself. The delineation of the field is typified by the preparation and weighing of the sample; the search of the literature by the solution of the sample and preparation for the chemical reaction; the experimental study by the actual quantitative reaction; and the fitting of the result of the study into the industrial picture by the operations of weighing and stoichiometric calculation.

Research and Cultural Development

Human welfare has advanced by taking advantage of experience. N. C. Nelson of the American Museum of Natural History has pointed out that man's cultural development, or his civilization, or, for that matter, his human classification, depends upon his use of implements. From the first bare-fisted ancestors who in desperation hurled sticks or stones in offense or defense, or to knock down food, a trace of culture came when they recognized the relationship between form and purpose. A sharp-pointed stick was best for stabbing, a thick stout one for clubbing, and a hooked one for reaching branches of fruit. But the first real culture came when man realized that he could so fabricate these natural implements as to improve them for the purpose to which he adapted them.

Now turn from our first human ancestors to the recent progress of agricultural science depicted by Gortner. "The retreating front of our forests has been closely followed by fields of waving grain. Long ago man selected certain seed plants as especially suitable for use as food sources and through generations these plants have been grown, cultivated and improved by wholly empirical methods. Only recently has the scientist undertaken a study of the nutritional requirements of both plants and animals, and of methods whereby new and improved varieties can be produced. Within less than a hundred years the sugar beet has been developed from only a fairly sweet root into

one of the principal sources of the world's sugar supply. Within the scientific lifetime of workers still active in our own agricultural experiment station (Minnesota), the northern limit for corn production has advanced from the southern border of this State until today it is approaching the shores of Lake Superior. It may well be that another generation will see the northern limit of profitable corn production advance across the international boundary. We have seen the average production of wheat increased from six to ten bushels per acre today, largely due to an increase in the knowledge of the factors necessary for adequate plant nutrition. Pineapple growing in Hawaii has become a profitable industry because of the discovery that minute traces of iron are necessary in order that chlorophyll may develop in the leaf cells. The increased production of our dairy herds and poultry flocks in no small measure reflects the researches of the biochemist in the field of animal nutrition."

The Development of Pharmaceutical Research

The beginnings of pharmaceutic science are traceable to tribal wizards, many of whom were superior in observation and curiosity. While many speak of pharmacy as the handmaiden of medicine, it is truly the companion of medicine. It provides the intimate knowledge of drugs necessary to the successful practice of medicine. Pharmacy was the precursor of chemistry. As medicine demanded a clearer conception of the constitution of drugs chemical study was encouraged, and chemists then introduced modern research methods into pharmacy. While chemistry has been regarded as a science and medicine a profession, pharmacy has been at once science, profession and art. The Parisians recognized the role of pharmacy in 1514 when they said "though the apothecary is always a grocer, the grocer is not necessarily an apothecary"; and James I of England declared that members of the Grocer's Company were but "traders," whereas the art practiced by the Guild of Apothecaries was a "mystery." No other profession has had so many names attached to its practitioners as pharmacy. Among those used in the English tongue alone are Druggist, Chemist, Apothecary, Pharmacist, Pharmaceutist, Pharmacopolist, Pharmacologist, Pharmacomath and Drugster.

The first technical achievements of pharmacy were the operations of decoction or extraction and distillation in the preparation of medicines and perfumes. This Galenic technic was the parent of chemical

engineering. While these methods were being elaborated and extended, inorganic chemistry developed with the preparation and use of metals, acids and salts, replacing earths and ashes in the materia medica. Then with refinements in the methods of extraction, and particularly as progress in the art of distillation improved the quality of spirit available, the manufacture of galenicals lead to the study of organic pharmaceutical chemistry, first made evident in the attempted analysis of plants.

Pharmacy has been wholly responsible for the introduction into the laboratory of many operations, refined though they have been afterwards by other workers. Thus the use of precise weighing and measuring apparatus was first necessitated in the preparation of medicines, and the accompanying specific gravity methods were devised for pharmaceutical purposes. Filtration likewise has come from the pharmacist's laboratory, and the greatest advance ever made in public health and sanitation, the building of the first municipal water filter in 1830, was based upon the knowledge of the pharmacist.

The increase of scientific interest in pharmacy had just as potent an effect upon organic and analytical chemistry as upon chemical technology. Thus venturesome souls who found crystalline compounds in their drug extracts began to break them down in order to determine their ultimate structure and then finally to attempt their synthesis. Chemical interest has swung between synthetic and analytical chemistry a number of times, but a lack of patience on the part of many investigators has kept the major interest on the synthetic side, to the neglect of the constituents of living tissues.

It seems a pity that some who only contribute an additional page to Beilstein, and with the barest chance of contributing to the organic chemical industries or the medical applications thereof, do not turn to Nature's laboratory, and develop for America and for pharmacy the field of phytochemistry. Many a young chemist, given the opportunity to engage in what we call pure research, has spent years in trying to block out a synthetic field in which there was not already keen competition for priority, when he needed only to go into his own yard and pull the first plant his hand touched to provide himself with a novel topic for investigation, and one fully as intriguing as any synthetic problem in the schools today. Happily, a few chemists are beginning again to realize the wealth of material the vegetable kingdom contains, and are producing splendid results. But as long as the

fashion for nutritional work prevails, food chemists will study solely the effects of vitamins on the animal body, without concerning themselves with the genesis and role in nature of these substances, and organic chemists will ponder over pharmacodynamically active groupings to be protected by patent but not to be put together by rote, when there is yet so much pioneering to be done in the vegetable kingdom.

As has been suggested earlier, the first contribution of science to Pharmacy was most likely in a physical way when extraction made possible the use of concentrates instead of copious doses of crude drugs. Next chemistry came to the fore and proved the existence of various potent principles in these concentrates, showing at the same time how they could be made available in much purer form. Finally chemistry in hand with medicine is studying the physiological functioning of organs and the pharmacodynamic effects of drugs. Heretofore the physician has diagnosed a disease and the pharmacist has provided a series of drugs to combat its manifestations. Now the time has come when not only the treatment of disease may be charted in advance but also the behavior of drugs. Some progress has been made in predicting, with fair certainty, the physiological action, as a drug, of many new organic compounds in advance of their synthesis. Perhaps in time we will be able to predict in the same fashion such things also as absolute toxicity, tissue irritation, acquirable habituation, etc., that for the present still make it necessary to conduct elaborate and time-consuming biological tests.

With the identification and characterization of the active principles of drugs well under way, science then turned its attention to the standardization of drugs. First of all came those principles that could be determined by comparatively simple operations such as extraction and weighing, and later those susceptible to purification and determination by reason of their salt-forming properties. Finally with the knowledge arrived at through physico-chemical studies, these standardizations have been improved in accuracy and new drugs brought within the reach of chemical standardization.

Biochemistry as an Aid to Pharmacy

Nature has seemingly placed a limit on the extent of chemical standardization by providing many very active principles having no striking chemical characteristics. Unable to use chemical reactions, it has been necessary to focus attention upon the pharmacodynamic

behavior of these substances. Through observation it has been found that some of these therapeutic qualities are susceptible of quantitative measurement. Among the most valuable have been those methods by which the stimulation of certain muscle fibers can be measured in terms of the force of their contractions. These developments, coupled with the ingenuity of the instrument maker and the skill of the mathematician in computing mean values and errors, have greatly increased the usefulness of some of our most potent and valuable drugs.

Equally important is the development of organo-therapy. Inquiry into the function of the various organs and glands by physiologists has brought to light the existence, not only of digestive enzymes, but also of a complex system of balance wheels or regulating agencies in the form of the products of the ductless glands. As a result we are now enabled to strengthen weakened bodily functions, restore other functions lost as a result of atrophy, and when necessary reinforce functions when increased power is required. Having accomplished both the isolation and/or standardization of the active agents in these organs, attention is being directed to the search for them in other tissues, their structure and synthesis, and, in the case of those now requiring injection, to less painful and inconvenient methods of administration. No one can follow the work of Kendall and of Harrington on thyroxin, of Banting and his associates on insulin, and of Doisy and others on sex hormones without being inspired by the thought of the possibilities for further work in that borderland where chemical and biological sciences meet.

Just a little over twenty years ago Funk called attention to the existence in foodstuffs of a substance that was a preventive of the disease beri-beri. This discovery opened a great field to public health workers, who now know of the existence of "deficiency" diseases and also of food accessory substances that prevent such conditions. These agents act in many ways, such as growth promotion and regulation, in fashion similar to the hormones of the ductless glands just mentioned. Some deficiency diseases are purely an impairment of organic function, such as the failure to deposit tissue or the withdrawal or deterioration of tissue already deposited, while others consist of bacterial infection of tissues rendered susceptible by deterioration. Therapeutics and nutrition are peculiarly intermingled in the use of the vitamins. The contributions of the pharmacist have been two-fold; providing means for the standardization of natural vitamin-containing products, and

developing methods for the preparation and stabilization of vitamin concentrates.

With our study of vitamins, we have at the same time advanced rapidly in our knowledge of metabolic processes and requirements. For example, we have learned that the mere addition of vitamin D to a diet is not adequate to relieve a condition of rickets unless the necessary bone-forming elements calcium and phosphorus are present in adequate amount in blood-soluble form. Of these elements, it appears that vitamin D is more concerned with the phosphorus metabolism, therefore affecting to some extent the nerve tissue as well as the bones, and depending for its successful functioning upon the absence of any sign of phosphorus starvation. Another illustration of the synergism of metals with each other and with vitamins and hormones is found in the essential character of copper as influencing hemoglobin regeneration by iron.

In addition to determining the natural functions of metals in the body, science has shown in late years many new ways in which the heavy metals may be successfully used therapeutically. Mercury and antimony have had their traditional uses remain in good repute. Gold, on the other hand, has disappeared almost completely from the materia medica, suggesting that its supposed therapeutic, like its monetary, value may have been based upon its scarcity. Apparently the chief uses of organo-metallic compounds in medicine are along the same general lines as those for which the purely inorganic salts of the same metals have been used, namely, as germicidal agents. The use of the complex organic compounds of metals is favored in part because of less evidence of tissue toxicity or irritation. The simple heavy metallic salts are quite generally protein precipitants, and when used the metal is localized, restricting its general action and intensifying its local effect, while at the same time the acid previously combined with the metal may be liberated, causing irritation and possible necrosis. The complex organic radical on the other hand prevents precipitation with protein and the accompanying irritation, and obtains broader distribution of the metal throughout the tissues to be treated. Still another method of metallo-therapy consists in administering organic compounds of the metals which are taken up selectively by tissues or organisms, oftentimes because the organic part of the molecule has been so constructed as to have the characteristics of a direct dye towards the tissues or bacteria. The application of these theories to

the use of organic compounds of arsenic and mercury has brought especially beneficial results.

The new developments in bactericidal agents are not, however, restricted to metallic derivatives or to compounds that act as direct dyes. It is now realized that the reactions of bacteria toward chemical agents of any type are like those of various families of plants and animals, and individual organs thereof. We have known for a long time of the tolerances of plants and animals for specific compounds. These same tolerances and specificities noted with plant and animal life seem to extend in the same way into the microscopic field of life as well, and a study of these peculiarities of chemical compounds and micro-organisms constitutes an important part of the newer work in the field of germicidal chemistry, especially in the direction of sterilization of the blood stream.

In bacteriology the field of research is not restricted to the search for new germicidal agents, but also includes profitable fields for investigation among the old and well-known agents. Your faculty and students have contributed in this way to the re-establishment of iodine in first place as a surgical and household germicide, a study in which our organization has been happy to have a part. Out of this work has come what is apparently a definite advance in the knowledge of iodine antisepsis, and probably a similar advance in the knowledge of the general use of germicides for topical application. I refer to the effect of solubility and reserve solvent power upon adsorption by tissues and the corresponding germicidal activity. It has been found in the case of iodine that the actual solvent power of the solvent for iodine determines the rate of adsorption, the nearer we actually come to balancing solvent power against amount of iodine present the more we increase adsorption rate and germicidal activity.

The Future for Pharmaceutical Research

It will prove a boon to Pharmacy if the developments of the last twenty-five years in the fields of organic products of vital origin, such as the vitamins and hormones, will serve to revive the science of phytochemistry, bringing thereto the refinements of modern physical chemistry and the new solvents provided by the organic chemist. The isolation of ephedrin and its commercialization has been a stimulus, and the discovery of regulators of carbohydrate metabolism, probably identical with insulin, in plants, is further evidence of the possibilities

of profitable research in botanical drugs. We trust that the action of the Research Committee of the American Pharmaceutical Association in confining its grants to problems of immediate pharmaceutical interest, and especially its support of an investigation of methods of drug extraction, will bring to the attention of schools and patrons the fact that there is much to be done in our own province.

Those who have profited through the practice of pharmacy should be the first to share the burdens involved in its advancement. Research in the development of new remedies or the refinement of old ones should be communicated to the professional society that will profit most from the study, and published in the journals supported by them. It has been said frequently during this period of depression that chemists should stand shoulder to shoulder more firmly than ever before in support of their profession. But when chemists and pharmacists stand aloof from each other, and both are diffident towards physicians, nothing but misunderstanding can arise. These three groups are united in a particular service to mankind, hence this service will best be rendered when mutual respect, confidence and the broader spread of scientific knowledge are made possible.

There are a few colleges of pharmacy, of which Philadelphia is a noteworthy example, that have been aided in their growth by reason of the prosperity that pharmacy has brought to business men. No group should appreciate more thoroughly than these men the debt that they owe to pharmaceutical investigators. It is very fine to lend one's support to the advancement of fine arts, and to show one's appreciation for the work of investigators in other fields by the endowment of scholarships which are to be absolutely free from dictation as to subject. But some have gone so far as to show the feeling that pharmacy should not receive such gifts because it has shown itself unable to make proper use thereof.

The answer is that pharmaceutical research, like any other form, requires men and facilities, meaning equipment and endowment. America has finally forged to the front in the physical and biological sciences because of endowments that have made possible adequate facilities for teaching and research. No great university department depends upon student fees for existence. But in pharmacy if the fee system were to be abolished half of our schools would pass out of existence. Pharmaceutical education is not only deserving of but entitled to a major share of the gratuities bestowed out of profits from the manufacture and sale of pharmaceutical products.

Perhaps pharmacy has been responsible also by failing to capitalize the worth of the scientific and technical side of the profession. Have we told those who have met with prosperity of what we have accomplished and what we can do? Do we see that our investigators receive credit for their work, or do we allow the credit to be blandly appropriated by other groups? And, equally important, do we encourage the investigative spirit in our schools, and allow those so inclined to devote a reasonable portion of their time to productive research?

I have a feeling that the thinking and doing pharmacists are showing signs of a less complacent attitude toward these things than in the years recently gone. It also seems to be a reasonable assumption that the generation of pharmacists now coming on through the medium of the four-year course, of full collegiate grade, will be even more insistent upon seeing that pharmacy receives recognition for all it accomplishes and proper support for what it hopes to accomplish. The mere holding of students in school for one or two additional years will not of itself mean a greatly increased number of scientific workers. Four years in other curriculums have not done this, and pharmaceutical training will probably not prove to be any exception.

The more thorough balancing of the curriculum will be productive of a different type of scholarship. There will be no excuse for any college to make of its curriculum a mere cramming course. The better assimilation of the subject matter of the curriculum will induce a spirit of inquiry on the part of the student that will in turn encourage the teacher in an investigative way. Some students at least will have the opportunity to come in contact with investigational methods while serving an apprenticeship under their teachers, so that we can anticipate the desire of some of these students to continue for graduate study.

Capacity for research is not measured by the length of training, but by the breadth and soundness thereof, and capacity increases with experience. A good brain in the laboratory will furnish leadership and direction for several pairs of hands. It is to be hoped that with the broader fundamental training of students these hands will be furnished and thus, as in other fields, greatly increase the amount of productive and scholarly research in our colleges and other laboratories. Then research in these fields will continue to be, as it has in the past, for the general welfare of humanity in the control or prevention of disease, and for the provision of additional comforts of life for all.

YEAST—IN WELFARE AND INDUSTRY*

By Dr. Arno Viehoever

"Yeast: Every granule a globule of life."

YEAST is a one-celled organism of microscopic size. It is about ten times as large as a bacteria germ. Under favorable conditions the cells combine to form giant colonies, several inches in diameter. While the cells have many characteristics in common with certain bacteria, they are classified with the molds and fungi, living upon inorganic and organic food. Yeast is physiologically characterized by its power to ferment sugar and has therefore been called sugar fungus "Saccharomyces." It is the yellowish substance produced during the alcoholic fermentation of sugared fluids. When the temperature is low, "bottom yeast" forms as a sediment; at elevated temperatures "top yeast" is formed as a frothy, flocculent mass.

Arno Viehoever, Ph. D.

Yeast is definitely different from protozoa, the one-celled animals, and from algæ, chlorophyll-bearing, mostly filamentous, plants. Yeast may occur anywhere, in soil or air, but is mostly found on fruits as grapes and plums; in beer or wine, in cider, in cottonseed meal, etc. It develops best in food, containing weak solutions of sugar or substances convertible into sugar. In jelly, left exposed in a warm room, yeast will grow readily. It cannot grow in dry sugar nor in highly sugared jam.

Yeast has come to be widely recognized as a valuable agent in nutrition and restoration of health, as well as an indispensable organism in important commercial processes generally referred to as "fermentation." It will be the aim in this brief survey to touch upon the major phases with sufficient detail to bring out the astounding significance of a minute form of plant life called yeast.

*One of a Series of Popular Science Lectures given at the Philadelphia College of Pharmacy and Science, 1932 Season.

2. Historical Data

"Long before Aesop wrote fables, poems were sung to Bacchus and epics were written over the brew kettle."

Alcoholic fermentation was known to man since ancient times. The cause of alcoholic fermentation was attributed very early to the precipitate forming in the course of fermentation. But the nature of the sediment and its action was long a matter of hot dispute. Only at the end of the eighteenth century did alcoholic fermentation receive earnest scientific attention. But not until the last years of the nineteenth century was the cause—yeast and its enzymes—definitely established.

In medicine, yeast was early recognized. In Eber's Papyrus, a medical treatise, written approximately 1500 B. C., a reference is made to the therapeutic use of yeast. Already at that time yeast was recommended as an ingredient in a prescription for constipation. Hippocrates and Pliny the elder used yeast as a curative agent.

Oldest is probably the use of yeast as an agency to leaven dough in bread making or to cause fermentation. A reference in the Bible is of interest (Exodus 13:17): "Unleavened bread shall be eaten seven days; and there shall be no leavened bread seen with thee, neither shall there be leaven seen with thee in all thy quarters."

The first record of the microscopic description of yeast is furnished about 1660 by Leeuwenhoek, the obscure Dutch pioneer and student of micro-life, who described yeast as small, round, or ovoid particles. The first chemical record, evidently, was provided by Cavendish, who observed the formation of carbondioxide gas during fermentation, of hydrogen gas during putrefaction. Lavoisier, as the first, formulated the process of alcoholic fermentation as follows: $C_6H_{12}O_6 = 2C_2H_5OH + 2CO_2$ (+ 27 Calories) which reaction, with the exception of certain minor reactions, is recognized as correct today. The sugar, according to Lavoisier, is split into two parts; one is oxidized at the expense of the other. Thus an oxidized and a reduced substance are formed, the fermentation process essentially is an oxydo reaction, the oxygen of the atmosphere having no part in the process. Thenard (1803) also added to the progress of knowledge when he noted that the deposits occurring in fermented liquids resembled brewer's yeast. Then Exleben (1818), Latour (1835), Schwann (1837), Kuetzing (1837), possibly independently, observed yeast as

a living organism and concluded that alcoholic fermentation depended upon the presence of living cells.

Berzelius attributed the fermentative activity of yeast to a catalytic force, and Liebig as well as Woehler, the foremost chemists of their time (1839) supported the physico-chemical explanation and bitterly opposed the biological theory that fermentation was due to a living form. In the highly scientific "Woehler and Liebig's Annalen" in 1839 appeared an anonymous article ridiculing the notion of yeast as a creature which eats sugar and excretes carbon dioxide and alcohol: "I am in the act of unraveling a new theory of vinous fermentation. I came upon the trail of this, until now so mysterious a change, in the simplest manner in the world and regard it as fully settled. This discovery too shows again how simple are the means of which nature makes use, to bring forth the most wonderful phenomenon; I owe thanks to the use of a remarkable microscope. . . .

"Beer yeast, dispersed with water, is dissolved under this instrument into endless pellets whose diameter is scarcely one eight-hundredth that of a line, and into fine threads which are unmistakably a sort of protein material. If one introduces these pellets into sugar water, one observes that they consist of the eggs of an animal; they swell, burst, and tiny animals are evolved from them, which multiply with inconceivable rapidity in a most unparalleled manner. The form of these animals deviates from the 600 hitherto described species; they possess the shape of a certain (Beindorf) distillation flask (without the cooling apparatus). The nozzle of the helmet is a sort of sucking proboscis which is lined on the inside with bristles one two-thousandth of a line in length; teeth and eyes are not noticeable; on the other hand, one can easily distinguish a stomach, intestinal canal, the anus (as a rose-red colored point), and the urinary secretory organs. From the moment that they have escaped from the eggs, it is observed that these animals gobble up the sugar out of the solution; very plainly it is seen as it arrives in the stomach. Momentarily it is digested, and this digestion is simultaneously and in a most concise manner distinguishable from the evacuation of excrements which follows. In a word, these infusoria eat sugar, evacuate from the intestinal tract alcohol, and from the urinary organs carbon dioxide. . . ."

Bèchamp in brilliant but forgotten experiments proved yeast actually responsible for the fermentation and also claimed the presence of "zymase" excreted by the yeast cells. Pasteur continued these

experiments and popularized the results. His geniality and scientific authority succeeded in overcoming for a time Liebig's physico-chemical explanation of fermentation. "The yeast," said Pasteur, "is a living organism, nourished and reproduced—and not as Liebig assumes, a transformation product of plant albumen, the decomposition of which stimulates the decomposition of sugar. "The sugar decomposition," Pasteur concluded, "is the source of energy needed for the life of the yeast. The peculiarity of the sugar destruction is the want of oxygen; fermentation is life without air." He showed that other fermentations as those causing the formation of lactic acid, butyric acid, the souring or the alkalinization of wine were definitely due to the action of living micro-organisms. He devised flasks, which permitted the demonstration that no fermentation of boiled liquids takes place, when germs from the air or cultures are kept out. He thus proved the impossibility of spontaneity of life. After listening to a doctor holding forth his objections to microbian doctrines, he replied: "Sir, your language is not very intelligible to me. I am not a physician and do not desire to be one. Never speak to me of your dogma of morbid spontaneity. I am a chemist; I carry out experiments and I try to understand what they teach me."

Pasteur looked for the enzyme "alkoholase" in yeast, but failing to find it in his extraction experiments, was led to the vitalistic fermentation theory, fixing the entire fermentation process, not only the ferment formation inseparably with the life of the yeast, and considering the fermentation at end with the death of the yeast cell. The chemist Liebig could have readily come to an agreement with the biologist Pasteur had the first worker accepted the formation of an enzyme in the yeast cell, and Pasteur conceded that even the living organism uses physico-chemical means during its metabolism. The discovery of fermentation in unorganized, germ-free liquids, prepared the way for the acceptance of the bio-chemical theory. Traube (1858) said: "The fermentation is induced through a chemical body—thus, is a chemical process, but the inductor is of organic origin; thus fermentation is a biological process. . . ." Buchner (1897) in splendid experiments proved the liberation of the enzyme "zymase" from the yeast cells and its subsequent action of fermenting sugar in the complete absence of yeast cells. The general terminology was also enriched by the yeast studies, as Kuehne adopted the name "enzyme" (meaning yeast, according to the Greek language) for the active ferment in bar-

ley extract and in almonds and thus caused its general use for ferments.

3. Structural and Physiological Characteristics

"Buried into the dough of bread, yeast lightens it and makes it more digestible,
Drowned in flat fruit juice, yeast changes it to sparkling wine."

GENERAL MORPHOLOGY

Yeast represents a group of typical, one-celled, chlorophyll-free molds, forming usually no mycelium and developing for reproduction cell divisions called budding and spores within vegetative cells called sporangia. The yeasts form no uniform, systematically sharply defined, group, but are distinguished by the appearance of their colonies and mainly by certain biological characteristics, as the formation of different fermentation products in the presence of various sugars. A differentiation is made between true and false yeasts, but even cells of the same species vary in their form, so that this characteristic cannot alone be depended upon. (Colonies are illustrated in Fig. 1.)

The true yeasts are classified as "saccharomyces" (sugarfeeders) and comprise egg-shaped or elliptical cells, mycel filaments with septa in some cases and spores with a membrane.

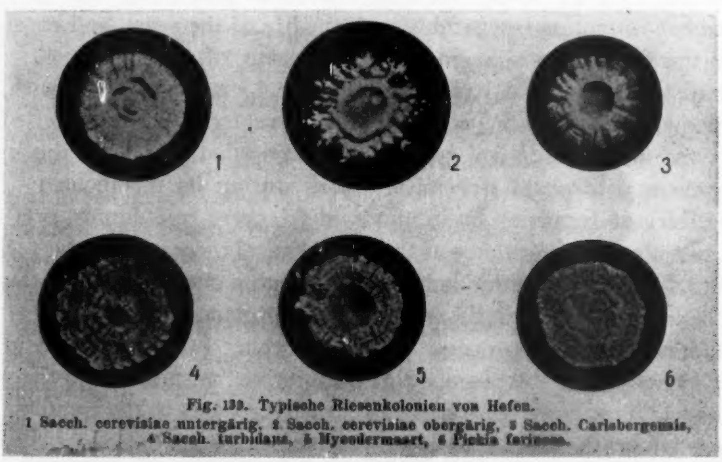


Fig. 1—Giant Colonies of Yeast.
1. Saccharomyces cerevisiae (Top Yeast of Beer). 2. Saccharomyces cerevisiae (Bottom Yeast of Beer). 3. Saccharomyces Carlsbergensis. 4. Saccharomyces turbidans. 5. Mycoderma. 6. Pichia farinosa.

Saccharomyces	Species	Temperature ° Celsius	Form	Spores	Spore Size in Microns (μ)	Source Remarks
Saccharomyces cerevisiae	Hansen	20-28 optimum	spherical, elliptical, ovoid	No. 1-4, -5	2, 5-6	Brewer's Yeast Top yeast in scum
Saccharomyces Pastorianus Pastorianus,	Hansen	5-28	elongated or pear shaped	1-4 (5-10)	1.5-3.5 5	Bottom Yeast [1] In wine
Saccharomyces intermedius, Pastorianus,	Hansen		slightly larger similar form	1-7	2.-5 [2]	
Saccharomyces validus,	Hansen		Form and size similar	1-7	2.-5	Spoiled turbid beer [3]
Saccharomyces elipsoideus,	Hansen	25 optimum			2-4	Ripe Grapes
Saccharomyces Marxianus,	Hansen		Similar to S. elips. Older colonies moldlike, mycelia similar to Monilia candida			Grapes
Saccharomyces exignus,	Hansen					Baker's yeast
Saccharomyces Bailii,	Lindner		Cells elongated, thickwalled, no scum formation			"Dantzig beer"
Saccharomyces Boutroux					4-5	Fruit juice
Saccharomyces mali,	Duclaux		6-12 u long, 4-7 u wide			Cider
Saccharomyces fragilis,	Joergenson		small, elongated			Kefir grains
Saccharomyces Hansenii,	Zopf		spherical to ellipsoidal	1-2	2-4	Cottonseed meal

[1] Gives bitter, disagreeable taste, causes turbidity of beer.
[2] Colonies developed after 14-16 days upon yeast water—nutrient gelatine show smooth margin.
[3] Colonies developed upon yeast water—nutrient gelatine show frinched, hair-like margin.

The yeasts enumerated in above table form white colonies; other yeasts, little investigated and possibly not belonging to the genus Saccharomyces, form pigmented colonies.

Saccharomyces Species	Pigment of Colors	Saccharomyces Species	Pigment of Colors
Saccharomyces conglomeratus	gray	Saccharomyces longus	red or pink
Saccharomyces sphaericus	gray	Saccharomyces flavescens	yellow brown
Saccharomyces glutinis	red or pink	Saccharomyces badius	yellow brown
Saccharomyces rotundus	red or pink	Saccharomyces niger	black

Normal yeast cells may be readily seen when magnified 500 to 1000 times. They are round or oval, measuring about three one-thousandths of an inch in diameter. The cells appear semi-transparent and show slightly granular globules. Vacuoles can be seen occasionally, but the nucleus is usually invisible, unless special staining is employed. Specific stains bring out better the presence and nature of cell content as fat, starch-like glycogen, volutin and nucleic bodies.

In nutrient solutions, as malt extracts or certain sugar mixtures, yeast cells reproduce with great rapidity. The cell walls, during germination, bulge out as buds; these buds grow nearly to the size of the parent cells and then separate as independent organisms, budding in the same manner. The well-known compressed cakes, according to Fleischmann, contain over one million of yeast cells, according to a newspaper clipping before me "as many living plants as seventy times the population of the world," thus bringing the number to 70 times 1000 millions—a sensational exaggeration.

SPORES

Under peculiar or adverse conditions normal genuine yeasts usually form spores. These spores form within the cell in numbers two to eight, depending to some extent upon the species of yeast. Saccharomyces cerevisiæ usually forms two to four spores per cell, each spore having its own membrane. The spores are visible without staining, showing a bright reflection of light. Upon staining with greatly diluted methylene blue only the membranes of the living spores are stained. The dead spores are stained immediately. Normal yeast is affected in its growth by all the common factors affecting living organisms: moisture, temperature, nutrient substances, light and air pressure. The optimum conditions of growth are applied, as far as possible, in the manufacture of yeast, discussed under cultivation.

The formation of spores, so important a morphological unit in the classification and preservation of cultures, is rather irregular and requires therefore special care and special media. In limited experiments carried out with the assistance of Mr. Brillhart, we observed the following results:

1. In normal nutrient agar spore formation of saccharomyces cerevisiæ was very slow, only four cultures out of twenty-four showed abundant spores after three to four weeks.

2. On gypsum block slants, prepared from 2 parts of powdered calcium sulphate with 3 parts of water, with and without lactose and grape juice, recommended for spore formation, unsatisfactory results were obtained.

3. On McKelvey's medium, containing a weak carrot infusion in agar with a little calcium sulphate added before tubing, fair results were observed.

4. On Goodkoma's medium, containing dissolved in water glucose ¼ per cent., salt ½ per cent., meat extract 1 per cent., agar 1 per cent., good sporulation was observed in twenty-four-hour cultures, kept at room temperature. Spore formation seemed almost 90 per cent. complete in seven days.

5. On potato slants few spores were found; partial drying out of the surface of the slants favored the formation evidently of spores.

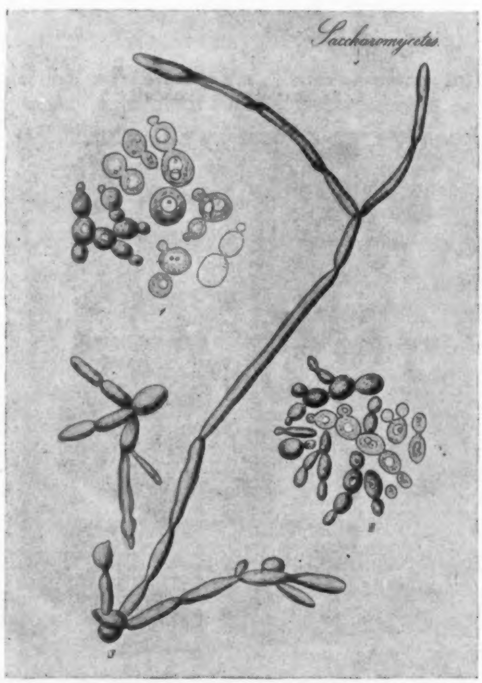


Fig. 2—Saccharomyces cerevisiae.

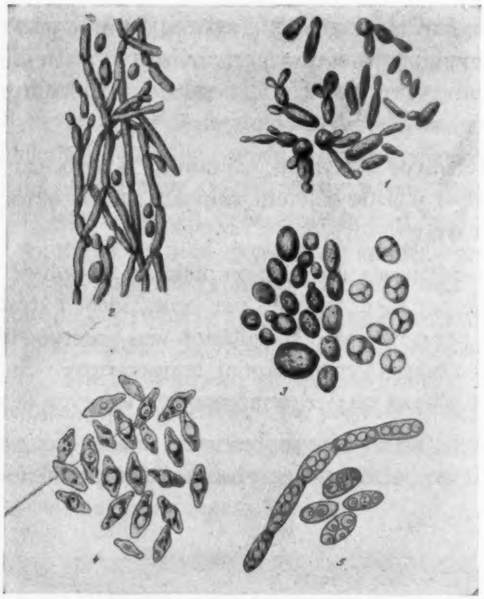


Fig. 3—1, 2. Saccharomyces validus; 3. S. cerevisiae; 4. Hansenia apiculata; 5. Saccharomyces Ludwigii.

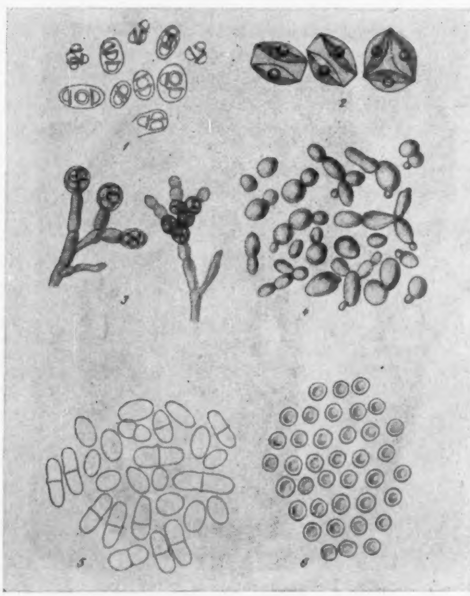


Fig. 4—1. Willia anomala; 2. W. Saturnus; 3. Saccharomycopses capsularis; 4. Saccharomyces elipsoideus; 5. Schizosaccharomyces octosporus; 6. Torula pulverrima.

6. In malt extract broth good growth was observed, but no satisfactory spore formation.

GENERAL PHYSIOLOGY

The chemical composition of yeast and the nature of its constituents represents an important part of our information. Interesting data are tabulated below for brewer's yeast, differing mainly in lower protein—and higher ash content from mineral yeast, prepared after Delbrueck from sugar, molasses, ammonium salts, superphosphate and potassium salts. The amount of cell substances as proteins, fat, glycogen and cellulose gum varies not only with regard to nutrition, but age and variety as well. Fat, usually present to the amount of 2 to 5 per cent. in the dry substance, increases to 10 to 13 per cent. in old cultures—and even to 52 per cent. (through "fatty degeneration") in one case of keeping the yeast in beer for fifteen years. The yeast membranes contain cellulose gum which characterizes the yeast extract—in contrast to meat extract—and the carbohydrate mannodextran. Glycogen, present mainly in animal organs as "animal starch," occurs up to 30 per cent. of the dry weight in yeast, while liver usually contains only 1 to 4 per cent., and muscles less. The caloric value of yeast is claimed to be double that of beef.

YEAST ANALYSIS*

	Dry Substance Per Cent.	*Moist Per Cent.*
Protein	52.41	14.15
Fat (ether extract)	1.72	.46
Glycogen	30.25	8.16
Cellulose gum, etc.	6.88	1.87
Ash	8.74	2.36
Moisture	....	73.00
	100.00	100.00

A cake of yeast weighs half an ounce.

*Reported by the Fleischmann Yeast Company.

ANALYSIS OF YEAST PROTEIN

	Dry Substance Per Cent.	*Moist Per Cent.*
Ammonia		8
Purine and pyrimidin bases		12
Guanin	4	
Adenin	4	
Cytosin	1.6	
Uracil	()	
Diamino-acids		20
Histidin and Arginin	10	
Lysin	10	
Mono-amino acids		60
Glycocol	5	
Alanin	10-15	
Valin	10-15	
Leucin	5-10	
Prolin	2	
Phenylalanin	8	
Asparaginic acid	3.5	
Glutaminic acid	6	
Tyrosin	2	
Tryptophan	.5	
Cystin and other sulphur compounds	2	
Oxyprolin	4.5	
Cholin	.5	
Glucosamin	.5	

ANALYSIS OF THE ASH

		Per Cent.
Phosphorus pentoxide	P_2O_5	54.5
Potassium oxide	K_2O	36.5
Magnesium oxide	MgO	5.2
Calcium oxide	CaO	1.4
Silica	SiO_2	1.2
Sodium oxide	Na_2O	.7
Sulphur trioxide	So_3	.5
Chlorine	Cl	trace
Iron	Fe	trace
		100.00

ENZYMES Yeast contains a mixture of several (over twenty) enzymes or biological catalysts characterized by their specific action. The tabulation, given below, lists the enzymes and products involved in their function and the process recognized as fermentation. This term fermentation evidently is derived from the Latin *"fervere"*—to boil, due to the gas formation, resembling effervescing or boiling, observed in saccharine liquid left exposed or placed in contact with the living ferment yeast. Becker (1682) was the first to report the fact that liquids containing sugar undergo spirituous fermentation. He believed that alcohol did not pre-exist in the wort, but is formed during the process of fermentation. He considered the intervention of air necessary to set the action going which he considered analogous to combustion.

Zymase, the principal enzyme, was likely among the soluble ferments observed by Bèchamp, who employed polarimetric measurements. These enabled him, before any other worker, to define and isolate a number of ferments to which he gave the collective name "Zymases," meaning ferments in the Greek language. "The cause of the inversion of the sugar is performed in the molds and in the yeast," said he, "and as the active matter when isolated acts in the absence of acid, this shows that I was right in allying it to diastase." Zymase is obtained by Buchner's method from yeast juice, prepared from ground-up yeast cells, mixed with water and siliceous earth, pressed in a powerful hydraulic press, filtered, diluted with water and precipitated with alcohol. It is a mixture of enzymes acting upon the four naturally occurring sugars, as may be seen from the tabulation. The enzymatic processes are indeed involved and still a subject of close study, especially in connection with regard to the molecular regrouping of substances involved in the fermentative process.

By means of these enzymes present in the yeast fermentations are effected which give this organism the dominating role in biological processes. As indicated in the Biological Survey below the type of sugars fermented depends much upon the species, variety or strain of yeast. The degree or intensity of fermentation surely depends upon the variety and strain. Conditions of nutrition undoubtedly affect all yeast action. To one such condition we shall refer in connection with the fermentation of sugar to glycerine. Of special interest may be that we observed a slight but definite formation of gas in a nutrient solution containing lactose, indicating that under certain conditions,

Enzyme	Substrate	Endproducts Formed	Remarks
A. Fairly large quantities in fresh yeast			
Invertase (Saccharase)	Sucrose (Saccharose)	Glucose and Fructose	
Zymase	d. Glucose d. Fructose d. Mannose d. Galactose	Alcohol and Carbondioxide	l. (levorotatory) sugar and other sugars as pentoses are not fermentable
Catalase	Hydrogen peroxide	Free oxygen and water	Significance in yeast metabolism unknown
Carboxylase	Pyruvic acid	Acetaldehyde and Carbondioxide	
Maltase	Maltose	Glucose	Maltose possibly also directly fermentable
Melibiase	Melibiose	Glucose and Galactose	Only in bottom yeast (differentiation from top yeast)
B. Moderate quantities in fresh yeast			
Endotryptase	Albuminoses, peptones, peptides	Amino—Acids	
Oxidase	Phenols and Tyrosine	Quinones and Melanins	Significance limited
Reductase			
C. Small quantities in fresh yeast			
Amygdalase	Amygdalin	Hydrocyanic acid, Glucose, Benzaldehyde	
Emulsin	B-Glucosides	Glucose or Phenol residue and alcohol	
Amylase (Diastase)	Starch		Presence questioned
Glycogenase	Glycogen		Significance in autofermentation and autolysis of yeast
Lipase	Fats	Higher fatty acids and glycerin	Significance limited
Rennet	Casein	Paracasein	
Trehalase	Trehalose	Glucose	Significance limited
Lactase	Lactose		Significance limited
Phosphatase	Zymophosphate (Hexose-phosphoric acid)		
Arginase	Arginine	Urea and Ornithin	
Desamidase	Acid Amides	Acids and Ammonia	
Gentianase	Gentianose	Gentiobose and Glucose	
Guanase	Guanine	Xanthine and Ammonia	
Nuclease	Nucleic acids	Purine bases, phosphoric acid and sugar	
Aldehydrase	Methylglyoxal—Acetaldehyde		Dehydration—Hydration
Raffinase	Raffinose	Melibiose and Fructose	
Carboligase			Synthetic, carbon fixing ferment

BIOLOGICAL SURVEY

Functional Yeasts	Fermentation of Dextrose	Saccharose	Maltose	Lactose	Formation of Alcohol	Oxalic Acid
S. cerevisiae	+	+	+	+*	+	—
S. Pastorianus	+	+	+	—	+	—
S. intermedius	+	+	+	—	+	—
S. validus	+	+	+	—	+	—
S. elipoideus	+	+	+	—	+	—
S. turbitans	+	+	+	—	+	—
S. Ilicis	+	+	+	—	+	—
S. Aquifolii	+	+	+	—	+	—
S. Sake	+	+	+	—	+	—
S. Cartilaginosus	+	+	+	—	+	—
S. pyriformis	+	+	+	—	+	—
S. Marxianus	+	+	—	—	+	—
S. exiguus	+	+	—	—	+	—
S. Bailii	+	+	—	—	+	—
S. Rouxii	+	—	+	—	+	—
S. Soya	+	—	+	—	+	—
S. mali	+	—	—	—	+	—
S. fragilis	+	+	+	+	+	—
S. Hansenii					—	+

*Original observation.

which we shall further study, lactose may also be fermented by the sugar fungus of beer.

4. Yeast-like Organism

Structural and Physiological Characteristics

"So near and yet so far."

In contrast to the cultivated or true yeasts many forms are known which have certain characteristics, either morphological or physiological, or both, seemingly placing them in a different class, namely, the "Wild Yeasts." Our information of these forms in general is, however, so limited that further study is required before they may be finally marked as undesirable. We anticipate that some of these wild yeasts will be harnessed by the unprejudiced biological engineer to do wonderful things—perform bio-chemical miracles.

Species	Cell Form	Spore: Form, Size, Number	Source	Function	Remarks
Hansenia apiculata R. Lindner (Saccharomyces—apiculatus Rees) (Species group ill defined)	Lemon-like budding on points		On varied fruits especially groups in soil and of vineyards		Spoils taste and aroma of wine
Torulaspora Delbruecki Lindner	Mostly spherical, budding on many points of mother cell almost simultaneously	Mostly spherical Mostly one in a cell	From American Ale. Possibly in slime secretion of German Oak	Ferments Dextrose Ferments Levulose	Shedding of membranes not infrequently
Zygosaccharomyces Barkeri Sacc. et. Sydov.			From cane sugar solution	Ferments Dextrose Ferments Saccharose, not maltose	Spores are formed after copulation of two cells
Zygosaccharomyces Priorianus Kloecker			From abdomen of honeybees	Ferments Dextrose Ferments Maltose, not saccharose	Spores are formed after copulation of two cells
Saccharomycodes Ludwigii Hansen (Saccharomyces Ludwigii Hansen	Slender, lemon-like, frequently with dull extended point mycelium with septa	Size 3-4 μ. Number 1-4 in cell (6-8 in cell)	From slime secretion of trees, mainly oak	Produces alcohol	
Saccharomycodes Behrensianus Kloecker	Large, oval, round	Size 4-4.5 μ. Number 2-3 in cell	From hops		
Saccharomycopsis capsularis Schioenning	Egg- or sausage-like mycel formation with septa	Flat globular 3.5-8 μ 4 in cell	From grass field soil of the Alps		Spores with 2 membranes

Species	Cell Form	Spore: Form, Size, Number	Source	Function	Remarks
Saccharomycopsis guttulatus Robin (Saccharomyces guttulatus Buscalioni)			From excrements of rabbits		Spores with 2 membranes. Spore membranes burst irregularly in germination
Pichia membranaefaciens Hansen (Saccharomyces farinosus Lindner)	Mycelium (Strong) cells elongated, elliptical	Semi-globular or globular-angular	From Dantzig beer, from slime secretion of elm. From white wine. From impure water	Causes no fermentation	Forms mycoderma-like, light gray, clastic scum on wort
Willia anomala Hansen (Saccharomyces anomalus Hansen)	Small oval, torula-like	Hat-like with protruding band. 2-3 μ 2-4 in cell	In impure yeast, in beer, in mash, etc.	Produces distinct fruit ester flavor	Causes turbidity in wort, then forms dull gray scum
Willia Saturnus Kloecker (Saccharomyces Saturnus Kloecker)	Spherical or elliptical	4-6 μ. Lemon-like with protruding band. 3 μ	From soil		Forms white shriveled scum
Willia belgica Lindner	Very similar to W. Baturnus, cells relatively small, thin-walled, lacking contents	Hat or lemon-like, with protruding band. 3 μ	From Belgian Beer	Produces no fruit ester flavor. Does not ferment dextrose, maltose, saccharose	Forms white shriveled scum
Schizosaccharomyces Pombe Lindner	Elongated, conidia of oidium—lactis like often in long chains, older cultures; rounded cells		From barley beer of negroes		Spores are often formed after copulation of 2 cells

Species	Cell Form	Spore: Form, Size, Number	Source	Function	Remarks
Schizosaccharomyces octosporus Beyerinck	Almost globular, sometimes mycel-like elongations	8 in. cell	From dry grapes of Greece, Asia Minor		Spores colored strongly blue with iodine. Spores are often formed after copulation of 2 cells
Schizosaccharomyces mellacei			From sugar cane of Jamaica		Spores are not formed
Torula pulcherrima Lindner	Resting cells: Globular with large fat drops. On wort: Small-celled budding masses		From grapes, plums		Spores are not formed
Schizosaccharomyces asporus			From melasses of Arrakrum		Spores are not formed
Mycoderma cerevisiae Desm.	Mostly elongated, elliptical or cylindrical mycel-like in colonies		From beer left exposed. From wine left exposed	Oxydizes alcohol Oxydizes organic acids Does not produce alcohol	Forms gray scum on beer and wort spores are not formed
Mycoderma vini Desm.	Very similar to M. cerevisiae		From white wine	Consumes practically all alcohol and free acid	Forms scum, up to 1 cm. thick, spores are not formed
Mycoderma cucumerina Alderhold			From scum in acid liquor of pickles	Consumes practically all alcohol and free acid	Spores are not formed
Monospora cuspidata Metchnikoff		Thin—needle-like —1 in a cell	From intestines of daphnia		Relationship to saccharomycetes in doubt
Nematospora cyyli Peglion	Budding occurs only at the ends of cells	Long, filamentous, with one long Hayella at one end	From spoiled hazel nuts		Relationship to saccharomycetes in doubt

5. Yeast Manufacture

"Man, the worker, always doing something new."

THE VIENNESE PROCESS

The commercial yeast is manufactured by either the Viennese method or that method which is known as the aeration method. Both methods are used in this country for the manufacture of yeast. The diagram, given below, as prepared by the Fleischmann Company, shows the manufacture of yeast by the Viennese method. According to Dr. Hawk and various collaborators, the following procedure is now followed on a large scale, having been continuously perfected since Charles Fleischmann in 1868 made and sold in this country the first pound of compressed yeast used by the American baker.

RAW MATERIALS AND MILLING PROCESS

Yeast is generally made from a mixture of grains—corn, rye and barley malt of the best selected quality are employed in varied proportions, according to the formula of the manufacturer. When unloaded from the freight cars or steamers at the yeast factories, the grain is subjected to a cleansing process by which all dust and any foreign substances are removed. It is then stored in grain elevators until ready for milling, whereupon it is cleansed again. The grains are ground separately in regular milling machines, the same type as used for grinding wheat in the manufacture of flour.

THE MASH

The preparation of the mash consists of setting the ground grains to soak in filtered water. This has the effect of softening the starch, and in order that the final solution may contain all the elements for nourishing the yeast cells, the different grains are treated in distinct ways; for example, corn is mashed at high temperature, the rye being put into the mash after the corn is "cooked." Malt at a lower temperature is added to convert the starch of the corn and rye into sugar. This is accomplished by the "diastatic" power of malt. The mash itself is sweet and contains no alcohol.

SOURING (Lactic) PROCESS

Pure culture lactic acid bacteria are next added to the mash. The temperature is carefully regulated and within sixteen hours the lactic acid bacteria have multiplied to such an extent that the mash has a distinctly sour taste. The lactic acid renders soluble and digestible the nitrogenous substances

Diagram of Yeast Manufacture

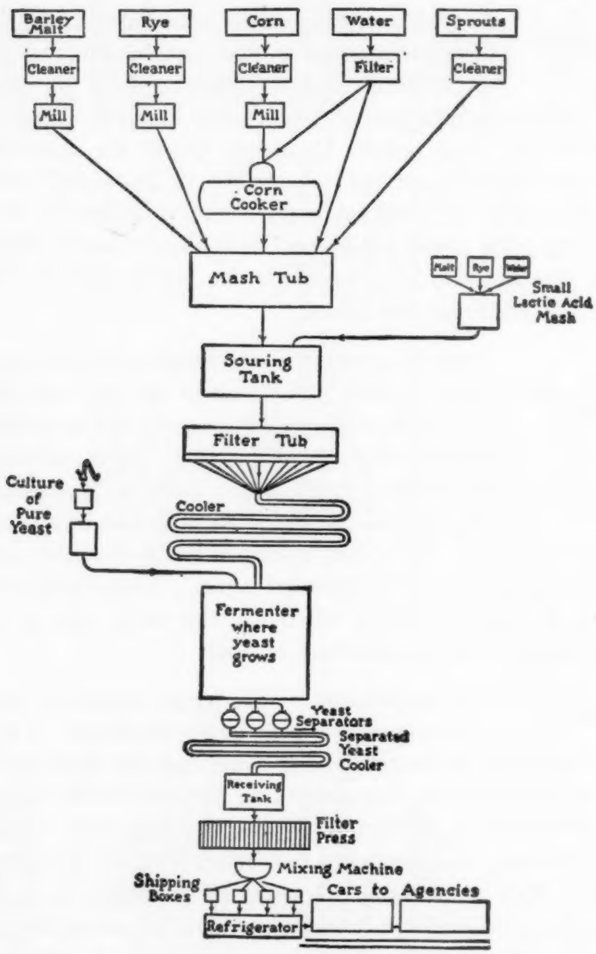


Fig. 5.

contained in the grain and thus prepares the proper food for yeast, at the same time insuring a healthy fermentation. Lactic acid has a beneficial effect in yeast making, just as it has in preventing infection in the human body, as was discovered by Dr. Metchnikoff, the famous Russian scientist and advocate of milk soured with lactic acid.

FILTRATION Upon completion of the lactic process, the mash is run into "filter tubs" having perforated bottoms; the solid particles of the grain are held back and a perfectly clear extract known as the "wort" is obtained by the filtration. To free the wort from other bacteria besides the lactic ferment, it is heated to a very high temperature.

FERMENTATION After being cooled, the wort is conducted by pipes into huge copper tanks (fermenters) twenty feet high. In these tanks, specially prepared, pure culture yeast is introduced. Compressed air is forced in, the oxygen in the air aiding the growth and reproduction of the yeast cells from the mother or culture yeast first introduced. The temperature of the wort is controlled by a system of cold water coils in the fermenters; the yeast cells under proper conditions of temperature and aeration multiply very rapidly and in about twelve hours a large amount of yeast substance is formed.

PURIFICATION AND PRESSING After development of the yeast cells to the point desired, separation of the yeast substance from the liquid or wort is accomplished by means of centrifugal separators in the same manner that cream is divided from milk. The yeast leaves these separators in fluid form like heavy cream and is conveyed by pipes through a cooling apparatus into a receiving tank and from there into a series of filter presses. Here the superfluous water is squeezed out and "compressed yeast" remains in the presses between the filter cloths. The yeast, after removal from the presses, is thoroughly mixed by machinery, packed by hydraulic pressure in eighty-pound boxes and placed in a large refrigerator.

THE AERATION PROCESS The aeration process uses a clear wort prepared from grain, and sometimes from molasses. The process consists of A. Preparation; 1. Grinding; 2. Mashing; 3. Souring of mash; 4. Filtering, and 5. Cooling of the wort. B. Fermentation; 1. Setting with seed yeast; 2. Fermentation under continuous aeration; 3. Separation of yeast by settling or use of centrifuge. C. Pressing and packing the yeast.

The improved aeration process gives a high yield of yeast (and a small yield of alcohol), chiefly because of the lower fermenting temperature, very thin wort, large amount of seed yeast and very heavy

aeration. While very good yeast can be made by this process—according to Hart—yeast made by the Viennese process, giving a smaller yield, is considered of better quality.

Growth of yeast is sluggish without air, as the sugar food is only used in part for growth, the other part being fermented into alcohol and carbon dioxide. In the presence of a great abundance of air yeast grows very rapidly, provided, of course, it is properly nurtured. As Mr. Veron, of Annhaeuser-Busch, writes, "Yeast has an almost unbelievable appetite, particularly for sweets. Imagine a man sitting down to breakfast and ordering himself 200 hot cakes, five gallons of syrup, six dozen scrambled eggs, five pounds of bacon, and fifteen gallons of coffee. Then consuming every bite of it to the last drop and looking around for more all within an hour's time. That ludicrous picture gives you a fairly good idea of how much yeast can eat. At eight o'clock this morning in our yeast factory we put 125 pounds of yeast down at one of our dining tables, which happens to be a big vat, and started feeding it. We brought a ton and a half of food for this yeast to eat; we dissolved its food in 7000 gallons of water—for yeast prefers to eat while swimming around. We set an electric blower going to supply the yeast with air at the rate of 1000 cubic feet per minute, and we kept the temperature nice and warm and made everything just as comfortable as possible. This afternoon at six o'clock all of the above ton and a half of food was gone. We decided the banquet had lasted long enough. Our guest took its departure down through some pipes and was spun around for a while through some centrifugal separators and neatly put to bed in another vat at the rather chilly temperature of 35° F. But in the orgy of feasting the yeast lost its girlish figure. Instead of weighing 125 pounds, as it did at 6 A. M., it went to bed weighing over 2000 pounds. Between sunup and sundown it took on almost twenty times its original weight. Vat after vat, hour after hour, day and night, this fantastic picture repeats itself hundreds and thousands of times in our yeast factory. Today there is tucked away a little vial containing about a spoonful of yeast in one of our incubators in the laboratory. Next week twenty-five million loaves of bread will be made from the progeny of this yeast—all grown from this original little spoonful, and every loaf of this bread will contain more yeast cells than are people on the face of the earth."

6. Industrial Uses

"Fermentation—the life basis of many industries."

ALCOHOL Ancient documents disclose that alcoholic fermentation was empirically known in its principal phases and utilized long before history was written. Fermented liquids, prepared from saccharine juices which had been allowed to ferment, were known in the earliest times—as wine, palm wine, cider, beer, and ale. We are told that Osiris among the Egyptians, Bacchus among the Greeks, Noah among the Israelites, taught the people the cultivation of the grape vine, and the fermentation of the grape vine to wine. On standing, grape juice did ferment and acquire a pleasing "kick." With barley extract and honey, upon standing, the ancients made their home-brew, with honey water their "mead." Incidentally the yeast scum from the beer vats—two thousand years ago—served the Castilian beauties of Spain as a facial treatment for their "flapper" complexion. Brewing soon moved out of the individual cellars into breweries and distilleries. Experts developed strains of yeast, specially suited for the brewing of beer, wine, and alcohol.

As we have mentioned, the amount of air provided during the growing and fermentation process has a great influence on the product formed. "Given an ample supply of air, while eating," states Veron, "causes yeast to obey the Volstead law and keeps the alcohol content of the drink well under ½ per cent. With the air cut off and gorged with sugar, it settles down, perfectly at home, in a vat of beverage containing as much as 18 per cent. alcohol."

The production of alcohol is effected not only by the fermentation of saccharine fruit juices, but for industrial purposes most economically by the fermentation of molasses, the cheap by-product of sugar refineries. Of course, much "grain alcohol" is also produced for "aldehyde free alcohol" by the preliminary conversion of starchy grains as barley, wheat, rye, corn, etc., and the subsequent fermentation of the mash, as we have learned in the previous chapter. Finally, the alcohol is distilled preferably in refractionating columns, to be used in various concentrations. After water, alcohol is the best known general solvent for raw materials and prepared substances as flavors, medicinal agents, as fuels, anti-freeze solution and many other products. About one hundred million gallons of alcohol are used yearly, about which an interesting separate story is written in volume 9 of the Popular Science Talks.

BREAD As the ancient Egyptians brewed beer out of wort and yeast, so did they mix dough and yeast in making bread. Their leaven was fermenting dough, "sour dough" reserved for use in the subsequent batch of dough. Yeast or leaven dough, containing it, constitutes the oldest method known for making bread of a light texture and a more palatable taste.

Prior to 1840 no baking powder was sold in the United States, and the leavening of bread in the households and among the bakers was done with yeast, or sour milk and soda. The home kitchen, as a place for bread baking, has in recent times been largely replaced by the bakery, the housewife has been replaced by the master baker or expert. The quality of yeast for baking from liquid yeast, obtained as a by-product from breweries and distilleries, sold from door to door by yeast peddlers out of buckets carted around, gradually improved. Now baker's yeast may be secured in varieties adapted in quality and strength to the special needs of the bakers.

Distributors of such yeast claim that three things are particularly necessary for the production of good bread:

1. The proper amount of acid development by fermentation, the acid effecting the softening of the gluten, developing and aging the dough.
2. Good mechanical development of the gluten of the dough by proper mixing.
3. Lively yeast action when the bread goes to the proof box. Enough gas must be produced to lighten and raise the dough.

The quantity of yeast used, it is claimed, has an effect upon the character of the bread. The best results in flavor and texture can be secured only by using a fair amount of yeast and a relatively short fermentation period. The temperature at which the yeast grows also has an effect upon both its own rate of growth and the products formed. Yeast grows very little at 40° F., but grows speedily as the temperature increases. The maximum or death-point of growth is about 120° to 130° F. The fermentation at temperatures between 75° and 85° F. is considered to give best results in the finished bread. At higher temperatures undesirable flavors are produced. As the fermentation time varies with different flours, this also must be controlled. An instructive and well-illustrated article on bread, with a

discussion of many varieties, is found in volume 10 of the Popular Science Talks.

INVERTASE Yeast furnishes the best source for the enzyme invertase, inverting cane sugar or sucrose into glucose and fructose. It has recently become of great commercial importance and various processes have been devised for the utilization of the inverting action in the production of "golden, sorghum, cane, and maple syrups and maple cream," of crystal-free honey, of fondant types of confectionery. The inversion of the sucrose increases the solubility of the total sugars, thus the density of the syrups; it checks the crystallization of the sucrose, modifies the flavor, and retards the drying of the fondant confections on account of the hygroscopic character of the fructose formed. Invertase takes an active part in the fermentation of cacao beans, preceding the roasting process. Being readily available, the enzyme invertase has been recommended for analytical determination of sugars as sucrose. For the determination of raffinose, the solution containing a mixture of sugars is first treated with invertase from top yeast, then with invertase and melibiase from bottom yeast. The degree of conversion is determined with the polarimeter after each treatment and the difference in rotation indicates the amount of raffinose in the mixture. We understand this method has been applied to factory control processes.

Invertase is readily demonstrated in autolyzed yeast, diluted with 100 times the amount of water. Autolysis is effected by grinding about 1 pound of yeast with an ounce of chalk, placing the resulting paste into a wide-mouth bottle, adding 25 cc. of chloroform and keeping the mixture for three to four days in a warm room, then precipitating the filtrate with equal volumes of alcohol, washing the precipitate with alcohol and ether—and drying over sulphuric acid.

ERGOSTEROL Yeast furnishes an important supply for this valuable oily substance. Ergosterol, having three double bonds and a hydroxyl group, can be activated by irradiation with ultra-violet to yield vitamine D, so essential a substance in food deficiency. The Medical Research Council of Great Britain has recommended as a standard that the unit of vitamine D be defined as the antirachitic potency of a quantity of a special preparation, corresponding to .00001 milligram of ergosterol used in its production.

For the preparation of the standard ergosterol, prepared from yeast, was purified and dried by carefully recorded methods, then irradiated in an accurately made alcoholic solution with rays from a mercury arc, the physical details measured and recorded with the greatest practical accuracy. The irradiation products were carefully freed from alcohol, dissolved in pure olive oil and the volume adjusted to a known concentration in terms of ergosterol used.

GLYCERINE

Glycerine is also a normal product of the alcoholic fermentation of sugar by yeast. It is therefore present in wine and beer in small amounts (up to 3 per cent.), as was originally shown by Pasteur, 1858.

The biochemist Neuberg (1912) and co-workers have shown that, in the presence of certain salts as sodium sulphite, sugar is fermented to yield as much as 25 per cent. of its weight in glycerine. This remarkable discovery was utilized on a large technical scale by the Central Powers in the great war for the manufacture of explosives. Then the shortage of fats and oils, yielding glycerine ordinarily, on account of the blockade stopping all such shipments, was very great. The possibility of producing glycerine in substantial amounts by the fermentation of molasses and other cheap sugar supplies deserves our special attention. American workers have verified the German findings and the detailed conditions for the biological production of glycerine are well known now.

PLASTICS AND ADHESIVE PASTES

Yeast alone or with fillers, treated with formaldehyde under high pressure and temperature, yields plastic masses, permitting the molding of various hard rubbers or celluloid-like articles, as doorknobs, cover plates, combs, frames, and buttons.

Waste yeast, on account of its high protein content and low price, is used for the preparation of adhesive pastes. Brewer's waste yeast yields a satisfactory paste when sulphurous acid or other substances inhibiting the fermentation process are added and the alcohol and excessive water is removed by concentration in vacuo. As the fermentation of sugar is prevented, molasses may be added during the process whereupon their alkaline salts react with the acid yeast substances, yielding a neutral non-drying paste. If hot alkaline solutions or acids of phosphorus, arsenic or antimony or hydrogen sulphide act

upon yeast or autolyzed yeast under pressure, mixtures are obtained which, upon concentration, filtration and possible addition of casein glue, yield satisfactory pastes. Their full utilization has probably been held back by the phenomenal development of the plastic resins of the bakelite type.

FERTILIZER The use of waste yeast on account of its high content in nitrogen, phosphorus, and potash has been promoted.

7. Nutritional Uses

"Know ye not that a little leaven leaveneth the whole lump."

FOODS Yeast is well recognized as a valuable corrective food. Certain commercial yeast preparations are indeed advertised as "a vegetable food." Yeast and yeast extracts are rich in vitamine B. Brewer's yeast is usually a dependable rich source of this complex natural vitamin, found also in certain animal and vegetable foods as egg yolk and salmon, cereals as wheat and oats, greens as spinach and kale. Vitamine B contains the heat-stable factor G and the anti-neuritic factor F. These vitamines have been found indispensable in our daily diet, in the maintenance of normal appetite, good health and good weight. Nervousness and symptoms of malnutrition are additional symptoms observed when the vitamin supply is curtailed.

Compressed yeast (from grain) should have a creamy color, a sweet odor, and should not have an unpleasant after-taste. It should be palatable and is consumed in cake form, suspended in water, milk, or fruit juices, or spread on bread or crackers.

Yeast extracts—preparations similar to meat extracts in color, consistency and taste, such as "Vegex"—are recommended for a spread on bread, etc.

The total value of human foods consumed in America in one year (1927) approached, we are told in statistics, the sum of eleven billion dollars, or 17 per cent. of all the total manufactured products. Baked goods amount to over one billion dollars in value. Two hundred million pounds of yeast was the entire consumption of yeast for the year 1931 for all purposes; one hundred and fifty million pounds alone were used in the baking industry.

Yeast, it is claimed, is finding a constantly growing outlet as a food in one form or another. "More yeast is being eaten than ever before, as people have become convinced of its value in their daily diet." It is being consumed not only as fresh, compressed yeast, sold so widely in well-known tin-foil packages, but as dried yeast. There are various brands of dry yeast, one called "Magic," the other "Bavarian style," another disguised as a preservative, sold in connection with the distribution of wine bricks or compressed grape bricks, as well as for berry, fruit and malt juices, "speeding up, clearing and settling the fermenting fluid." Some yeast is specially grown to obtain optimum vitamine potency, the flavor is improved, and it is claimed to surpass, even though dry, any fresh compressed yeast on the market in actual value. Yeast, furthermore, is sold in combination with cereal products, milk, ice cream, candies, chocolate, with tonics and bouillon. The bouillon cubes are made from the extract of brewer's yeast and are claimed to be used by the U. S. Public Health Service, the American Red Cross, and the medical profession.

Especially during the great war, yeast attained a significance for food purposes in Germany. It was shown that "mineral yeast," prepared from sugar (molasses), ammonium salts, magnesium sulphate, superphosphate and potash, produced protein and that that yeast has practically the same food value as brewer's and baker's yeast. Yeast has been recommended as a remarkable food concentrate, partially replacing meat, having three times the nutrient value of beef, and serving to overcome the weakness of and lack of appetite in diabetic patients, possibly on account of its high (2 per cent.) content of lecithin or nucleic substance. Its suitability for food use in hospitals, prisons, community kitchens, its effect on improving both nutrient value and taste of food, has often been emphasized. Workmen receiving one to three ounces daily showed increased vitality and alertness.

Food	Pre-war Price for 1 Kilogram Mark	In 1 Kilogram Calories	In 1 Kilogram Proteins	For 1 Pre-war Mark Calories	For 1 Pre-war Mark Proteins
Blood Sausage	1.80	1880	99	1044	55
Cervelat Sausage	2.60	4360	176	1677	68
Liver Sausage	1.90	3360	129	1756	68
Eggs (Hen)	1.20	1670	126	1391	105
Cheese (Emmentaler)	2.40	4040	295	1693	123
Beef (somewhat fat)	1.53	1370	210	896	137
Cheese (not fatty)	1.60	2830	350	1764	210
Food Yeast	1.50	4520	about 500	3013	333

An amount of 5 per cent. of yeast added to bread dough also was found advantageous. Of special interest is a comparative (pre-war) tabulation by Bandrexel of heating units (calories) and amounts of proteins contained in certain foods, showing that yeast heads the list.

FEEDS The value of yeast in feeds has been well established. Especially during the winter months, when both the amount of beneficial ultra-violet light as well as the supply of vitamins in the usual food is reduced, the breeding of common flies—needed for laboratory experiments—has been made possible by the daily supply of yeast. Similarly in my own experiments with transparent animals the breeding in winter was greatly facilitated when yeast was fed to them.

Fresh yeast, when fed near the place of production, mixed and boiled with other feeds with low nitrogen content, yields a remarkable fodder for cattle and pigs. Equally, dry yeast proved an excellent food for all domestic animals, showing its equal food value to Liebig's high-quality meat meal.

8. Medicinal Uses

"One's judgment is no better than one's knowledge."

The food value of yeast is especially obvious when ascertained in connection with food-deficiency diseases. Restricted diets, often low in vitamine B (F and G) will cause harmful secondary effects. Dr. Russel M. Wilder, of Chicago, in the *Journal of the American Medical Association,* November 14, 1931, reported two cases of pellagra developed in patients kept on a special diet for epilepsy, as follows: "In the two cases referred to, the addition of brewer's yeast alone, without the alteration of the diet, promptly resulted in a cure. Since then I have made a practice of including yeast in all my epileptic diets and thus far have not again encountered this complication."

The beneficial effect of yeast on growth was illustrated in the following rat experiments, carried out in connection with a study of baking powders: "Four groups, each group containing six to eight rats, were selected for experiments on growth. Biscuit leavened with yeast, phosphate baking powder, tartrate baking powder, and alum baking powder were used, and with the exception of the leavening agency used in the biscuit, the food of the animals in each group was identical. The diet from Monday to Saturday, inclusive, consisted exclusively of biscuit. Cheese and cabbage, but no biscuit, were fed

each Sunday. The experiment lasted from February to October, 1920. The diet was undoubtedly deficient in nutritive value, but all the animals fared alike. At the end of fifty-five days the yeast rats had gained 106 grams; tartrate, 97; phosphate, 95, and alum, 76. All the animals seemed to be normal throughout the experiment except those of the alum group. . . ."

Restricted diet given to diabetic or obese people also may reduce the B-vitamine content to too low a level. Dr. H. C. Sherman concludes in an article published in the *Journal of the American Medical Association,* November 14, 1931: "A liberal intake of vitamin G contributes to a better than average nutritional condition and thus to what McCollum and Simmonds have aptly termed 'the preservation of the characteristics of youth.'"

The U. S. Public Health Service has adopted the use of brewer's yeast for the successful treatment of pellagra of the South.

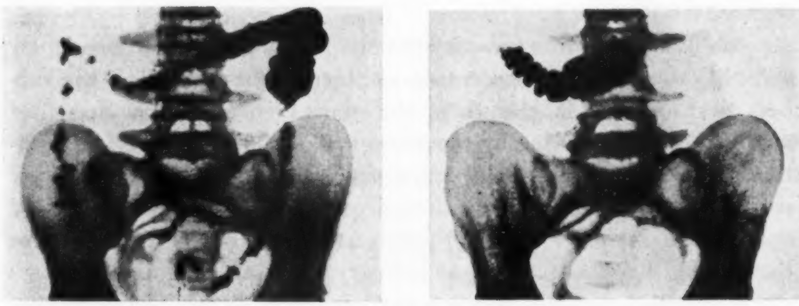
Yeast has been helpful in cases of anemia, convalescence and in the building of immunity. An interesting compilation of findings published by distinguished investigators and physicians concerning yeast therapy was distributed in 1930 by the Standard Brands Corporation. Here the food value, the therapeutic value, the chemistry and the physiology as well as the factory production of yeast are briefly discussed. Drs. John R. Muelin and Henry A. Mattill, from the physiology laboratory of the University of Rochester, New York, have experimented with human and animal subjects (dogs) to determine the effect, laxative or not laxative, upon administration of yeast. They observed:

1. A remarkable increase in the bulk of stool, which persisted for several days after the ingestion of yeast was stopped. Several of the students were compelled to evacuate two to three times a day when three cakes of compressed yeast (one before each meal) were taken. No increased moisture content was noted.

2. As a laxative effect in increased weight in thirteen out of fifteen of the tests and increased moisture in two-thirds of the tests. There was not only an increase in the absolute elimination of nitrogen, but an increase in the percentage of nitrogen in the dried stool. Evidence is found for the utilization of yeast protein as also in the value for the total nitrogen in the urine.

3. The estimation of phenols in the feces and urine indicate that putrefaction is somewhat diminished by the ingestion of yeast.

4. The uric acid of the urine shows a marked increase when three cakes of compressed yeast were eaten each day and becomes even higher in the control period immediately following.
5. Boiled yeast does not produce so much laxative effect (moisture and weight) as raw yeast; it is more easily digested than raw yeast.
6. Four cakes of yeast gave a marked laxative effect (softer movement) when fed to dogs of nine and ten kilos on a perfectly constant diet which otherwise was slightly constipating.



a. b.

Fig. 6—X-ray Picture of Colon.
a. X-ray of constipated colon showing retention of feces after passage of main fecal mass.
b. X-ray of normal colon after passage of fecal mass leaves colon clean.

The laxative effect of yeast was also readily observed in my own unpublished experiments with transparent animals.

It is generally conceded that regular elimination helps to remove the cause of many common ailments. Thus yeast has proven helpful in the removal of pimples, blackheads, boils, and carbuncles, and various gastro-intestinal disorders.

Bandrexel, in a survey of uses for waste or excess yeast, reports the beneficial use of yeast as a preventative and even cure of mouth and hoof disease, of anthrax and other diseases of domestic animals.

There are some voices, who consider the claims made for yeast and "the virtues extolled by our standard bearded scientists" much exaggerated. In an article entitled "Quackery in the Ads," published in "Advertising and Selling," September 1, 1932, Kablet and Schlink, of Consumers Research, state: "In an occasional case yeast is helpful, in most cases for which it is urged it serves only to delay proper treatment, and in some cases it is decidedly injurious." Unless supported by experimental evidence to prove their contention, the authors lay

themselves open to the criticism of exaggeration in condemning to the extreme what others have praised to the extreme. Time will tell!

Conclusions

The knowledge of yeast, of its composition and of its value in welfare and industry, has been furthered by comparatively few workers. However, the last one hundred years of study have established its unquestioned value in various important fermentation processes, as alcohol, beer and wine production, in bread making, as an adjunct through its rich vitamin content, in relieving food deficiency, and as a therapeutical agent.

Its use as a source for enzymes and vitamines and their commercial utilization is a very recent development. Remarkable is the success, first achieved largely under the stress of extreme war needs, of manufacturing glycerine by the biological method of yeast fermentation. Such examples greatly encourage further researches for new uses. Admittedly the classification of yeasts is still incomplete; in fact, quite unsatisfactory. Much progress may therefore be expected, for the benefit of welfare as well as industry, from an increased thorough study of yeasts, some of which we call, in favor, "true," some we condemn, often in ignorance of their potential value, as "wild."

"Yeast, like Africa, is always yielding something new."

MEDICAL AND PHARMACEUTICAL NOTES

Residual Effects of Chlorine Gas—In the *Medical Bulletin* of the Veterans' Administration, Volume 9, No. 3, for January, 1933, there is the first report on the residual effects of warfare gases. The report deals with the use of chlorine gas, gives a number of case histories, and a summary. While somewhat lengthy, the report should be studied by all those concerned with the efficiency and humanitarian aspects of chemical reagents used in warfare. The report grows out of the studies of a committee officially appointed to study exhaustively the residual effects of the various gases. Those other than chlorine will be reported in further numbers of the *Medical Bulletin,* which is for sale by the Superintendent of Documents, Washington, D. C., at ten cents a copy, or on a subscription basis at fifty cents a year. We can give here only the summary and conclusions, which follow:

(1) Chlorine gas as used during the World War had a predilection for the respiratory tract, so that anatomic residua of the bronchi or lungs developed in an appreciable number of men coming in contact with it.

(2) The principal anatomic residua noted in the series studied were chronic bronchitis, emphysema, and pulmonary tuberculosis. Accompanying the residua was the usual symptomatology present with these conditions.

(3) In those cases in which pulmonary tuberculosis developed following chlorine gassing, preëxisting quiescent or arrested tuberculous foci were present at the time, which were reactivated as the result of: (1) Trauma to the pulmonary parenchyma; (2) a lowered resistance brought about the inflammatory reaction.

(4) The method of study of these cases precludes the drawing of statistical conclusions, inasmuch as the patients selected were those who were most likely to have residua due to gassing.

(5) As a result of an intensive clinical study of the afterhistories of ninety-six men who had been gassed with chlorine, it was found that nine showed definite anatomic or symptomatic residua which were attributable to gassing. In seven instances the relationship of the disabilities to chlorine gassing was considered questionable. In eighty instances no relationship was found between the disabilities present at the time of this study and chlorine gassing.

(6) Of the nine positive cases, five gave evidence of pulmonary tuberculosis; three of the latter had a coexisting emphysema. Three of the positive cases showed evidence of chronic bronchitis; of these,

one had a coexisting emphysema. Of the nine positive cases, a total of four showed evidence of emphysema.

(7) In reviewing the clinical records of the subjects who gave evidence of having been gassed, it was found that in a number of instances there was a history of a respiratory disease for which the claimant was treated prior to or immediately after the gassing. In such instances it was difficult to decide the role played by chlorine in the causation of the disabilities found at the examination. Accordingly, the relationship of chlorine gassing to the disabilities in such cases was considered questionable.

In a number of instances the data as to gassing or as to the presence of certain disabilities while in the military service were conflicting, so that such cases were also classified as questionable.

(8) In a number of the clinical histories of ex-service men who had been gassed with chlorine, there were deficiencies of various kinds, so that it was thought best to consider such cases as negative. Some of the deficiencies noted were: fragmentary histories, conflicting evidence of gassing, and symptoms or disabilities which had their inception either before or after the date of gassing.—*(Bull. Ind. and Engin. Chem.)*

ANTIDOTE FOR STRYCHNINE POISONING—Strychnine poisoning may be cured by two modern sleeping potions, it appears from a report to the American Medical Association in Chicago, Ill. Successful use of these two medicines in eleven cases is described by Drs. G. F. Kempf, J. T. C. McCallum and L. G. Zerfas of the Lilly Laboratory for Clinical Research, the Indianapolis City Hospital and the Indiana University School of Medicine.

The two modern medicines are isoamylethylbarbiturate, sometimes called sodium amytal for short, and sodium pentobarbitol. They are known to induce sleep in restless, suffering patients. Directions for their use in strychnine poisoning are given by the Indianapolis doctors in *The Journal of the American Medical Association.*

Ordinarily, poisoning of any kind is treated by emptying the stomach and preventing the absorption of the poison into the system. Because strychnine is very quickly absorbed, these measures are usually unsuccessful, and treatment must be directed at counteracting the effects of the poison on the system.

Many drugs have been used for this purpose, but have not been satisfactory. Doctors have been searching for an antidote that would control the convulsions, get the poison out of the body, and supply oxygen so that the patient does not suffocate. Death in strychnine poisoning is due either to exhaustion or to suffocation. The difficulty with most of the older antidotes for strychnine is that if much strych-

nine has been taken, the amount of the antidote necessary to counteract its effects would be fatal in itself.

The two drugs used by the Indianapolis doctors seem to avoid this difficulty, as they may be given in large doses without bad effect. They stopped the convulsions promptly and generally put the patient to sleep but without interfering with his breathing. The drugs were usually injected into a vein, but are also effective when given by mouth, it was found.—*Science News.*

Maleic Acid—Rancidity Preventive—Maleic acid, a cheaply and easily produced synthetic compound, has been found to be of value in keeping edible fats and oils from getting rancid. Dr. G. R. Greenbank of the U. S. Department of Agriculture, who made the discovery, has applied for a public service patent on its use for this and similar purposes. Under such a patent, the product can be used freely by anybody, and no one can establish a monopoly.

Dr. Greenbank was led to his discovery by a project in chemical research, with the object of finding why some oils and fats kept naturally better than others. He did not succeed in learning this, but did learn that the natural "better keepers" contained minute quantities of unidentified organic acids.

Then he tried adding acids of known composition to oils and fats, and soon found that maleic acid, added in a proportion of one part to ten thousand of the oil to be preserved, would enable it to stand without turning rancid for about three times as long as untreated samples of the same oils.

Dr. Greenbank has tried this method on many fats and oils used as food and in the industries, including butterfat, butter, lard, and the oils of cottonseed, peanuts, corn and sesame. He has also tried it on such food products as milk powder and pie-crust, and he believes it will be useful in the cereal industries.

The chemistry of maleic acid's efficiency in preventing rancidity is not yet known. Dr. Greenbank thinks it possible, however, that it operates by stopping the formation of peroxides, which are intermediate steps in the respirational-digestive processes of the bacteria and other fermentive organisms that oxidizes fats and oils, thereby splitting off the acids that give the rancid odors.

Maleic acid is now made by manufacturers of photographic reagents and sells for a few cents an ounce.—*Science News.*

NEWS TEMS AND PERSONAL NOTES

FOUNDERS' DAY EXERCISES

The 112th Anniversary, Philadelphia College of Pharmacy and Science

THE 112th anniversary of the founding of the Philadelphia College of Pharmacy and Science was celebrated February 23d with a special convocation at which the honorary degree of master of pharmacy was conferred upon Dr. George Denton Beal, one of the directors of the Mellon Institute of Industrial Research at Pittsburgh. Dr. Beal then delivered at the exercises an address, printed elsewhere in this issue, on "Advances in Pharmacy Through Scientific Research," in which he reviewed the relation of pharmacy to other sciences and pointed out many instances of the ways in which the practice of pharmacy has stimulated research and scientific advancement not only in pharmacy but also chemistry, bacteriology, biology and physiology.

Dr. George Denton Beal.

The evening of Founders' Day at the College was featured by a testimonial banquet to Professor Frank Xavier Moerk, who is completing his fiftieth year as a member of the teaching staff at the Philadelphia College, where he now heads the department of analytical chemistry and is one of the executive officers of the faculty.

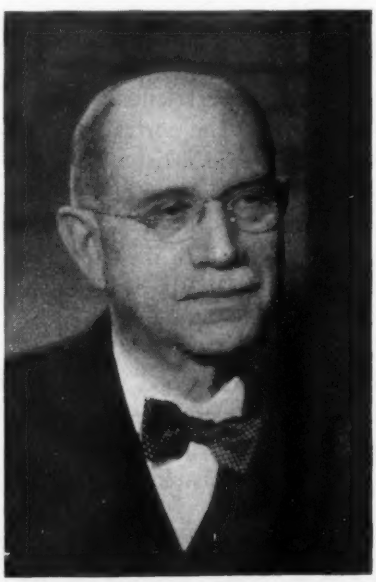
A unique feature at the testimonial banquet was the graphic portrayal by undergraduates in the dramatic society of outstanding events in Professor Moerk's career. This dramatic presentation was arranged by Registrar John E. Kramer, 1925.

Felicitations of the board of trustees were extended by Joseph W. England, 1883, its chairman, who is head of the scientific department of the Smith, Kline and French laboratories.

Dr. Henry V. Arny, 1889, dean of Columbia University College of Pharmacy, greeted Professor Moerk as one of his most distinguished students.

For the faculty of the Philadelphia College, Dean Julius W. Sturmer spoke in happy vein of his many years' association with Professor Moerk.

Henry Brown, well known Scranton, Pennsylvania, retail druggist, whose three sons all have been students at the Philadelphia Col-



Professor Frank X. Moerk.

lege, presented Professor Moerk with a framed and illuminated scroll on which were inscribed the signatures of sixty-four of his former students now living in and near Scranton. He also presented a bag of gold, the proceeds of which Professor Moerk plans to devote to the purchase of additional equipment for his laboratories.

Dr. B. Franklin Stahl, 1884, Philadelphia College trustee and well-known physician in Philadelphia, spoke on behalf of Professor Moerk's classmates and recounted many of the joys, thrills and problems of their undergraduate days.

On behalf of the undergraduate students, Frank P. Kelly, Jr., a senior in pharmacy and son of Colonel Frank P. Kelly, 1895, retail druggist in Carbondale, Pennsylvania, extended their good wishes and presented for the students a completely equipped desk for Professor Moerk's use.

Arthur Osol, 1925, on behalf of his colleagues in the analytical chemistry department, presented an onyx fountain pen set for use at the desk.

James Q. Mackey, senior in pharmacy, and son of Joseph Q. Mackey, 1900, presented Professor Moerk with a specially inscribed membership key in the Natural Science Society, of which Mackey is the president.

The climax of the evening was the unveiling of an oil portrait of Professor Moerk which was presented to the Philadelphia College by his colleagues and other friends. Dean Charles H. LaWall, 1893, made the presentation. The portrait was painted by Mrs. Mary Sturmer Jones, an accomplished artist who is the daughter of Dean Sturmer. The portrait was accepted for the Philadelphia College by President Wilmer Krusen.

Professor Moerk responded to the greetings of his friends with an interesting recital of some of the well-remembered events of his career and ended with a moving appreciation of the testimonial tendered him.

In addition to the personal good wishes extended by the more than 300 of his friends who were present at the banquet, Professor Moerk received hundreds of telegrams and letters from all parts of the world. Mrs. Moerk sat embanked in a veritable bower of floral tributes.

Dr. Lewis C. Scheffey, 1915, Philadelphia physician who is president of the Philadelphia College Alumni Association, acted as toastmaster. Dr. J. W. E. Harrisson was chairman of the committee of

arrangements. Vocal selections were rendered by the Philadelphia Rotary Club quartet and by a quartet from the Bethune-Cookman Institute of Daytona Beach, Florida. Dancing concluded the evening.

County Medical Society Holds "Pharmaceutical Night"—The regular meeting of the Philadelphia County Medical Society, January 25, was devoted to pharmaceutical discussions, in which many graduates of this College participated.

The joint committee in charge of the program was headed by John C. Walton, 1910, president of the P. P. A., for the P. A. R. D., and Dr. Francis Ashley Faught for the P. C. M. S.

The first speaker of the evening was John M. Woodside, 1903, a member of the Pennsylvania Board of Pharmacy, who spoke on "Pharmacy's Part in Safeguarding the Public Health." Dr. Horatio C. Wood, Jr., professor of materia medica at the College, led the discussion of his paper.

Charles T. Pickett, 1891, secretary of the P. A. R. D., spoke on the "Constructive Influence of Retail Druggists' Associations."

John C. Walton spoke on "Professional and Commercial Aspects of Pharmacy." Discussion of his paper was led by Dr. E. Quin Thornton, 1889, professor of therapeutics at Jefferson Medical College.

Discussion of the paper by Dr. George C. Yeager on, "Dispensing by Physicians," was led by Ambrose Hunsberger, M. C. C., 1908, who is recording secretary of the College.

A feature of the meeting was the exhibit of U. S. P. and N. F. preparations, arranged in the Medical Society building by the following members of the teaching staff in pharmacy at the College: Dr. E. Fullerton Cook, 1900; Dr. Adley B. Nichols, 1917; Jacob L. Nebinger, 1885; and Frederick R. Schrey, 1929.

BOOK REVIEWS

PRINCIPLES OF PHARMACY. By H. B. Mackie, Member of Board of Examiners for England and Wales of the Pharmaceutical Society; Head of the Pharmacy Department, Brighton Technical College, England. Publisher, J. and A. Churchill, London; 281 pp. Price, 10s. 6d.

"For a new time there is needed a new education. You cannot run a world reborn with the senescent ideas of a world that has passed away."—H. G. Wells. Thus does Mr. Mackie open the general introduction to this splendid new volume and one fully appreciates just why he does so when the book is examined. From the first to the last page it is replete with the newer thoughts and ideas which are logical explanations to many pharmaceutical processes and problems.

It is primarily a book of applied physical chemistry, the various phases of the subject being considered from a practical standpoint bringing one to realize that herein lies the explanation of many reactions which heretofore have been unexplained or possibly accepted with a matter-of-fact attitude.

The book is divided into six sections each dealing with a different general subject. The first of these is Solution, under which we find individual chapters on Ionization, pH, Buffer solutions, Solubility product, Iostonic solutions, etc. Section Two deals with the subject of Disperse Systems, being divided into Colloids, Surface and Interfacial tension, Viscosity, Adsorption, Emulsions, etc. The third section treats the question of the Change of State, Solid to Liquid, Liquid to Gas, or vice versa, Distillation and Sublimation. Part Four considers the subject of Extraction, Solvents, Processes, Clarification, Standardization and Storage. The fifth section discusses enzymes and the sixth is devoted to the question of Sterilization. At the end of each chapter is found a review of the products of the British Pharmacopœia directly related to the subject under consideration and discussed in the light of these new concepts. An appendix is devoted to a splendid bibliography, to a chapter on methods of calculation, an alcoholmetric table and also a set of logarithms.

The manner in which each subject is considered gives a splendid opportunity for thought and study, and without a question anyone

who studies or reads the book will be inspired to master the facts and seek still more detailed information on the same subject. Just enough is given to pave the way for one who really wants to know and is anxious to obtain the maximum in practical applications. Naturally, as in the case of physical chemistry in general, the book does not read like a novel, but one must have a good basic education to fully grasp the facts as they are presented. For the advanced student, or for one who is going into laboratory work, it can be highly recommended, and as a matter of fact all students would be better off were they to be given a subject of this type which would make them throw off their sluggish natures and actually arouse their thinking powers.

On the whole the book is comparatively free from errors, the most unfortunate of which appear in the chapter on Calculations, where, in presenting a shortcut method of multiplication, two errors creep in which make it difficult to determine exactly what the true procedure is.

Adley B. Nichols.

TEXTBOOK OF PHARMACEUTICS, Third Edition. By A. O. Bentley, Head of School of Pharmacy, University College, Nottingham, England. Publisher, Bailliere, Tindall and Cox, London; 900 pp., 234 illustrations. Price, 15s.

The third edition of this book appearing six years after edition number one speaks well for the author. Fundamentally it is a text for students, but inasmuch as the author is alive to the newer developments in pharmacy and has incorporated special chapters on the newer theories, the book also becomes of special interest to others.

Part One, dealing with the pharmaceutical history of Great Britain, in quite entertaining and should be of particular interest, of course, to British pharmacists, as a knowledge of one's professional development cannot but make that profession more interesting.

Part Two treats of the usual pharmaceutical principles and apparatus such as weights and measures, heat, etc. However, the chapters on osmotic pressure, electrolysis and hydrogen ion concentration, adsorption, colloids, theory of emulsions and enzymes, a number of which have been prepared by specialists in the field in question, bring the section right up to date and add materially to the value of the book. A knowledge of these particular phases of pharmacy have greatly changed our understanding of many phenomena and pharmacists al-

ready in the field will do well to bring themselves up to date with material as it is presented here.

Part Three deals with the problems found in dispensing, covering items such as pills, powders, cachets, capsules, incompatibilities, etc., each subject being considered in a general way and also from the standpoint of difficulties arising in specific cases.

Part Four covers pharmaceutical preparations, such as waters, elixirs, lotions, etc. Official products of the present British Pharmacopœia and the Codex are considered and discussed as well as many items which were previously official and still used to a considerable extent.

Unfortunately, however, while the ingredients for a particular preparation are listed and directions are given for its preparation, no quantities are mentioned. This may be in conformity with general procedure abroad, but the book would be more valuable to Americans, particularly those along the eastern seaboard, if quantities were included with the formulas.

Part Five consists of about fifty pages devoted to Pharmaceutical Biology, being a consideration of Vaccines, Sera, Culture Media and Bio-assays. A small appendix is also attached, being a table of doses and solubilities, arranged in alphabetical form.

Americans using the book must of course remember that the English system of weights and measures differs from our own, for otherwise serious errors might occur in following some of the formulæ which are given.

This book could be added to any pharmacist's library to advantage and of course would be more than worthwhile in England.

Adley B. Nichols.